Can Caesarean section improve child and maternal health? The case of breech babies.

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Abstract

This paper examines the health effects of Caesarean section (CS) for children and their mothers. We use exogenous variation in the probability of CS in a fuzzy regression discontinuity design. Using administrative Danish data, we exploit an information shock for obstetricians that sharply altered CS rates for breech babies. We find that CS decreases the baby's probability of having a low APGAR score and decreases the number of family doctor visits. We find no significant effects for severe neonatal morbidity or hospitalizations. While marginal mothers are hospitalized longer after birth, we find no effects of CS for maternal post-birth complications or infections. Although the change in mode of delivery for marginal breech babies increased costs by 4 percent of baseline spending, the health benefits indicate that CS is the safest option for these children.

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1. Introduction

Since the 1970s, many developed countries have experienced an increase in the use of Caesarean section (CS) for childbirth. For example, in the U.S., the overall CS rate rose from 20.7 percent in 1996 to 31 percent in 2006 (MacDorman, Menacker and Declercq, 2008).[2] Critics argue that changes in the population of biological mothers cannot solely explain this huge increase. While the procedure has life-saving effects for some groups, the use of CS has been extended to patients for whom the medical indication is not clear (Shearer, 1993; Declercq, Menacker and MacDorman, 2006).

As a CS typically costs more than a natural delivery, economists have primarily analyzed non-medical reasons for the increase in CS use and its economic consequences for health care systems (see, e.g., Gruber and Owings, 1996; Gruber, Kim and Mayzlin, 1999). However, to evaluate the cost efficiency of increased CS use, we need to factor in consequences for patients' health. The only existing economic study that includes health effects into the analysis is Currie and MacLeod (2008). They find that increased CS use after tort reform does not coincide with improved infant health at birth measured as the APGAR score. Our study extends the existing research in two ways: first, by examining short- and longer-run health consequences of CS for children and their mothers, and second, by evaluating the direct economic impact of these consequences.

The main challenge to our analysis is selection into CS based on expected returns. We deal with selection into treatment by using a regression discontinuity design and high-quality administrative data from Denmark. Our design allows us to investigate the effect of CS for the relevant pregnancies, namely the ones at the margin of either having a CS or a natural birth. We exploit an information shock to obstetricians (OBs) that discontinuously increased CS rates for breech babies at term. Breech babies account for around 4 percent of all births and around 20 percent of all performed CS in Denmark (authors' calculation based on data

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[2] Diagnostic groups that often or always lead to CS use include multiple births, placenta praevia, earlier CS, and high risk of emergency CS due to pregnancy complications (Danish National Board of Health, 2005*b*).

from Danish National Board of Health, 2005*a*).[3]

Our analysis of Danish data provides evidence that is more broadly applicable: For example, in the U.S., close to all breech babies are delivered by CS (Lee, El-Sayed and Gould, 2008). This high CS rate for breech babies may partly be driven by other factors than underlying health–such as liability rules or financial incentives–and thus not be optimal for babies at the margin. The lack of variation in the U.S. data rules out an evaluation of the costs and benefits of CS for these marginal babies. Thus our analysis for marginal CS babies in Denmark provides instrumental knowledge that is relevant for other countries with highly developed health care systems and high CS rates for breech babies, such as the U.S..

The information shock we exploit is the dissemination of the multi-center, multi-country "Term Breech Trial" (TBT) in 2000 (Hannah et al., 2000). It randomly allocated mothers with babies in breech position at term to either planned vaginal birth or planned CS, and concluded that planned CS is superior with respect to child serious neonatal morbidity and to perinatal and neonatal mortality.

While highly cited at time of publication, today several concerns exists about the TBT and the external validity of its findings (see, e.g., Turner, 2006; Glezerman, 2006). For example, in contrast to the protocol, not all mothers had an experienced OB present during labor, twins were included, different countries had different practices (e.g., with respect to external cephalic versions before labor) not accounted for in the randomization. In addition, the importance of the "serious morbidity" outcome measure has been challenged, as this measure combines various measures with potentially different longer-run consequences.[4] Importantly, given that in some countries very few women agreed to be randomized (e.g.,

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[3] Babies that have not turned head down in the womb by week 37 of the pregnancy are considered breech at term. While breech position is more frequent among preterm babies, who move around in the womb more actively before term, among babies at term breech position is as good as random.(Danish National Board of Health, 2005*b*; Tharin, Rasmussen and Krebs, 2011) Why some babies do not turn head-down in the last part of the pregnancy is unclear. Similarly, we do not know why most babies turn around. While most breech babies have not turned for unknown reasons, rare conditions that correlate with breech at term are congenital anomalies,placenta praevia, tumors, and a large amount of amniotic fluid.

[4] Longer-run follow-ups of the TBT show no significant differences between groups. A number of country-specific observational studies have at most shown minimal differences in short-run outcomes for breech babies according to the mode of delivery (e.g., Kotaska, 2004; Glezerman, 2006).

one woman from Denmark), the non-compliance among trial participants is likely to be influential in the TBT's intention to treat (ITT) analysis and may impact the conclusions we can draw from this analysis.

Using a decade of Danish administrative data, Tharin, Rasmussen and Krebs (2011) show that the TBT elevated CS rates for breech babies in Denmark. We extend their analysis in three ways: First, we focus on data closer to the TBT, thereby exploiting local exogenous variation induced by the information shock. Second, as opposed to earlier ITT analyses, we consider health effects for the marginal breech baby delivered by CS. This analysis examines the immediate effect of expanding Danish CS rates to a relevant "next-in-line patient group". Third, to examine persistent health effects, we consider longer-run child health outcomes.

Our first-stage results show that, in line with earlier findings, breech babies born after the TBT dissemination have a significantly higher probability of being delivered by CS. This increase is driven by higher parity children—in accordance with stricter selection of relatively uncomplicated cases into CS. This result contributes to a growing literature on the driving forces behind increased CS use. This literature has focused on technological innovations in the procedure itself; other technologies, such as monitoring the child's heart rate (continuous cardiotocography (CTG)) (Zarko, Declan and L., 2006);[5] "physician style", i.e., geographic variation that remains after control for factors such as maternal risk profiles (Baicker, Buckles and Chandra, 2006; Epstein and Nicholson, 2009); and physician-induced demand (e.g., Gruber and Owings (1996); Gruber, Kim and Mayzlin (1999); Grant (2009); Triunfo and Rossi (2009)). Finally, and studied in the U.S., liability rules may contribute to increased use of CS. Currie and MacLeod (2008) discuss the notion of "defensive medicine"—by which OBs attempt to reduce legal liability risks—and the impact of this behavior on childbirth practices. They find that certain types of tort reforms increase, and others decrease, procedure use. In line with the finding that liability matters for physician behavior, a very recent study based on U.S. data is the first to show that physicians react to medical error (and

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[5] Several randomized trials show that the use of CTG increases CS rates. However, the evidence on health effects of CTG is mixed. Studies show that while CTG decreases the probability of neonatal seizures, it does not lead to reduced prevalence of cerebral palsy or infant mortality.

related litigation) and increase CS rates as a consequence (Shurtz, 2013).

We add to this literature with the finding that newly available information for OBs can rapidly affect the use of CS. By studying a context in which financial incentives for OBs are at most modest and indirect, we highlight the importance of newly available information. This finding also relates to results from other studies that highlight the impact of new information on medical procedure use, as in Price and Simon (2009), Del Bono, Francesconi and Best (2011) and Anderberg, Chevalier and Wadsworth (2011). While these previous studies have focused on patients' responses, our study examines a case in which the released information was subject to an expert debate and was not broadly discussed in the public media.

Our second-stage results show that the marginal baby is in better health at birth, measured as having a higher five minute APGAR score. Extending the analysis to longer-run outcomes, we find that the marginal CS child has fewer general practitioner (GP) visits in the first two years of life. At the same time we find no persistent health effects for the marginal baby with respect to severe neonatal morbidity and hospitalizations in the first three years of life. For mothers, we find that CS prolongs post-birth hospital stay but–potentially because we lack precision–we find no significant effects on the probability of post-birth infections and complications.

Our results are stable across specifications and largely independent from the functional form chosen in our regressions. We find no indication for jumps in other mother or child observable characteristics at the cut-off, which (if present) would invalidate our RD design. Given that we find that the prevalence of breech pregnancies is smooth throughout the cut-off, we rule out manipulation of mothers' treatment status or changes in coding practices. We find no indication for changes in other technologies (such as ultrasound for earlier detection of breech or external versions of breech babies) that could account for changes in outcomes. Finally, we find no effects for placebo groups of mothers with high CS probabilities or for placebo cut-offs.

To examine the economic consequences of our findings, we calculate the changes in costs for the marginal breech babies delivered by CS after the TBT. We consider costs for the mode of delivery, mothers' post-birth hospitalization and children's GP visits. Ideally, we should compare these extra costs to the mean costs for marginal mothers before the TBT. Given that we lack this information, we compare the increase in costs to the pre-TBT overall level of expenditures for breech births. We find that, as a consequence of the TBT, the overall costs related to marginal breech deliveries increased by what corresponds to around 3-4 percent of the overall expenditures in the pre-TBT period. This increase is driven by higher costs for maternal post-birth hospitalizations. However, we cannot include potential positive long-run health benefits (e.g., induced by improved APGAR scores). Thus we may overestimate the impact of the TBT on health care expenditures.

2. Breech pregnancies and the Term Breech Trial (TBT) in Denmark

During the 1990s, the mode of delivery for breech babies was a topic of great attention among OBs in many countries. As breech babies face an elevated risk of oxygen deficiency and injuries during labor, vaginal breech births are on average more complicated than births for babies in cephalic presentation (i.e., head-down position). Consequently, breech babies at term have a higher risk of CS than babies in cephalic presentation.[6]

To ensure adequate treatment of breech babies, the Danish Society of Obstetricians and Gynaecologists (DSOG) provides detailed guidelines for the handling of detected breech pregnancies (see, e.g., Danish Society of Obstetrics and Gynaecology, 1998).[7] In the 1990s (before the TBT), the DSOG recommended the following procedures: OBs and midwives were to monitor the pregnancy closely, and OBs were to attempt to perform an external

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[6] For the period considered in this paper, Appendix Table 8.1 shows summary statistics for Danish breech and non-breech babies at term and of higher parity than one, respectively. Comparing the two samples, we find that breech and non-breech mothers are similar in a range of observable background characteristics. For example, breech and non-breech mothers have similar percentages of university degrees and pregnancy complications unrelated to breech (such as pre-eclampsia and diabetes). Thus we conclude that, given the observable characteristics at hand, breech pregnancies are as good as random.

[7] Although in Denmark ultrasound diagnostics are not routinely performed after week 20 of the pregnancy, midwifes tend to detect breech babies when examining the mothers' wombs externally and listen to the babies' heart rates. If the midwife suspects breech position, the mother is referred to ultrasound diagnostics. Around 15-20 percent of breech babies remain undetected until the onset of labor (many have most likely turned around in the womb often and thus they are hard to detect.)

cephalic version, i.e., to turn the baby around.[8] For babies still in breech position, medical professionals and mothers decided on the mode of delivery.

To be eligible for attempted vaginal birth, mothers had to meet a set of criteria defined by the DSOG, e.g., in their 1998 guidelines: adequate pelvic diameter, estimated birth weight of the baby below 4000g, frank or complete breech position,[9] and exhaustive information of the mother on risks and benefits of the procedure. For all vaginal birth attempts for breech babies, the DSOG required the presence of an experienced OB during labor. Furthermore, the hospital had to have access to pediatricians and have a specialized intensive care unit, and the medical staff had to follow clearly defined steps in the handling of labor (including guidelines for the inducement of labor, the use of analgesics, the maximum duration of labor, and the suitable maneuvers for delivering the baby).

Despite these high selection criteria, by international comparison the Danish maternity wards performed a high percentage of completed vaginal breech births throughout the 1990s. This observation is especially true for higher-parity breech babies, of whom around 37 percent were born naturally throughout the late 1990s and until the dissemination of the TBT (see table 1). At the same time, both in Denmark and many other countries, the debate among health professionals on the optimal mode of delivery for breech births at term remained lively—partly due to lack of evidence from credible randomized control trials (RCTs). Such evidence became available on October 21, 2000, when "The Lancet" published the results of the TBT (Hannah et al., 2000).[10]

The TBT included 2083 women from 121 centers in 26 high- and low-neonatal mortality countries during 1997-2000. Women who met the inclusion criteria were randomly allocated

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[8] In general, around half of these attempts were (and remain) successful.

[9] "Frank breech position" means that the baby's hips are flexed and its knees are extended. "Complete breech position" means that baby's hips and knees are flexed but the feet are not below the baby's buttocks (Hannah et al., 2000).

[10] The TBT ended prematurely, as an interim analysis showed significant differences between treatment and control groups. "The Lancet" fast-tracked the TBT results and published them only 6 months after the last randomization. Critics point out that the short trial period made accounting for longer-run effects impossible and that fast-tracking left important questions (such as the interpretation of results found for countries with high or low neonatal mortality) unresolved (Bewley and Shennan, 2006).

to either an attempted vaginal birth or an elective CS.[11] The TBT concluded that elective CS is superior to planned vaginal birth for breech babies who meet the TBT inclusion criteria. Babies in the elective CS group saw significantly lower risks of perinatal mortality, neonatal mortality, and serious neonatal morbidity. Additionally, the positive health effects of elective CS were bigger in low-neontal mortality countries. The study found no difference by planned mode of delivery with respect to maternal morbidity or mortality in the short run.[12]

While the scientific debate on the validity of the TBT results is still ongoing, the TBT was a ground-breaking trial, with over 500 registered cites in the Web of Science to date (October 2012). The dissemination of its results had a major impact on national guidelines for the handling of breech pregnancies across countries (Turner, 2006; Rietberg, Elferink-Stinkens and Visser, 2005; Phipps et al., 2003; Carayol et al., 2007). For Denmark, Figure 1 shows the percentage of CS for all singleton pregnancies and all breech pregnancies from 1996 through 2006. The graph is centered around the second half of the year 2000 and shows half-yearly means. While the CS rate is smooth for all singleton pregnancies, the probability for a CS increases sharply from 75 to 83 percent for breech pregnancies at time 0.

Several sources strongly suggest that this increase of the CS rate for breech babies was caused by the dissemination of the TBT results among Danish OBs. First, the DSOG scheduled an extraordinary meeting on December 4, 2000, when about 200 OBs, gynacologists, and midwives discussed the TBT. This meeting disseminated the TBT findings to all OBs and hospitals in Denmark (Clausen, 2003).

Second, the DSOG discussed the TBT at their annual meetings in 2001 and 2003. As these meetings often lead to changes in the national guidelines, they have consequences for OB practice. The report from the 2003 meeting summarizes a survey response from Danish maternity wards in 1999 and 2001 on their practices for breech pregnancies. Of the 28

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[11] The study's protocol included singleton babies in frank or complete breech position at term, below 4000g, without fetal abnormalities, or other indications for a CS, such as placenta praevia. Some women must have been in labor at the time of randomization and informed consent. In this case "the CS was undertaken as soon as possible" (Hannah et al., 2000, p.1376).

[12] A systematic review from 2003—including TBT data—concluded slightly differently, i.e., found a small elevated risk of maternal morbidity for mothers with planned CS (Hofmeyr, Hannah and Lawrie, 2003).

wards (78 percent) that answered the survey in both years 22 wards (79 percent) reported that the TBT publication affected their policy for breech pregnancies. Six out of 28 wards recommended elective CS as the default for breech positions before the TBT, whereas 18 out of 28 wards recommended CS after the TBT publication.[13]

Third, although no change in national DSOG guidelines occurred in the year 2000/2001, guidelines changed at the hospital level. The 2001 guidelines from the fifth largest maternity ward in Denmark state, "We [the maternity ward] cannot continue to present attempted vaginal birth as a safe alternative to elective CS. We have to put the numbers on the table. Most women will chose elective CS in this situation [i.e., if the TBT results are presented]" (Aalborg Hospital, 2001, p. 4; authors' explanations in brackets). Fourth, Tharin, Rasmussen and Krebs (2011) confirm a strong first stage, i.e. an increase in CS percentages around the TBT dissemination.

Taken together, all the available information suggests that the dissemination of the TBT results in Denmark changed the "best practice" for breech births—and did so rapidly. Thus we use this exogenous variation in the CS rate for breech babies to evaluate the health effects for the marginal child. Our strategy entails the condition that OBs' change of behavior, rather than maternal self-selection (potentially based on unobservables correlated with outcomes), drive the increase of CS use. We find it likely that this condition is met for the following two reasons:

First, the TBT was heavily debated among experts rather than in the public media. Access to the relevant information was available in an expert arena. This statement is supported by the difficulties that we experienced when searching for information on the TBT and its impact in Denmark. We have found no evidence for broad media coverage of the TBT around its dissemination to medical professionals in Denmark. Thus we argue that (locally around the cut-off) the rapid change in CS probability was driven by OB behavior, not maternal request.

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[13] No published data available. According to Henrik Nyholm, the OB who carried out the survey, the TBT was a driving force behind this change towards increased CS use for breech babies (Nyholm, personal interview 2011).

Second, even if mothers gained information about the TBT results, it was very difficult for them to select into hospitals according to their knowledge on, e.g., the hospitals' propensity to perform a CS for breech babies. In Denmark pregnant women regularly consult their GP and midwife, and only in the case of complications are they referred to OBs. In the first trimester, the GP assigns the women to their hospital of birth.[14] Breech presentation, however, is diagnosed late in the pregnancy. Thus mothers cannot chose their hospital according to their knowledge about hospital policies for breech births. We provide further evidence for this statement and other threats to identification in section 5.4.[15]

To credibly argue that the information mechanism drives the change in CS rates, we have to rule out the possibility that other factors impacting OBs drive the change. As OBs (and health care in general) are publicly funded, we can rule out changes in their economic incentives as driving the change in practice.[16] While the Danish hospitals are increasingly reimbursed according to their activities (pay for performance), hospital revenues allocated according to their activities were only around 10-20 percent in the period that we consider and do not change at the cut-off that we study (Ministry of the Interior and Health, 2003). Additionally, as we will show, given that the reimbursement for a "complicated" vaginal birth is very similar to that for a CS in Denmark, we should not expect hospitals to perform more CS's for breeches as a results of activity-based reimbursement.

3. Empirical Methods

To overcome the evaluation problem that we never observe the two potential outcomes for individual i—$Y_i(1)$ if exposed to treatment (i.e., having a CS) and $Y_i(0)$ if unexposed (i.e., not having a CS)—we choose a fuzzy RD design. Given that CS mothers differ from other mothers in baseline characteristics, some of which are unobservable to the researcher but

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[14] In principle, mothers are free to chose another hospital than their default hospital (if there are available slots in hospitals other than their closest hospital). However, in practice close to all mothers give birth at the hospital closest to their residence.

[15] While the differences in hospitals' baseline CS rate for breech babies before the TBT dissemination could be an additional source of variation, we have too few breech births per hospital-month-cell to pursuit an analysis based on hospital variation.

[16] However, as CS's are easier to schedule, OBs could face incentives with respect to leisure time.

impact outcomes, and given that doctors assign mothers to treatment according to expected gains, a simple comparison of outcomes for CS mothers and mothers giving birth naturally in a regression model is likely to be biased.

While the RD design does not offer randomization for eliminating this bias, it provides "local randomization" (Lee and Lemieux, 2010): We exploit a discontinuity in treatment status that is generated by the cut-off in our observed assignment variable X, calender time. Breech births before December 4, 2000, are in the control group, while breech births after this date are in the treatment group. Given that pre-TBT trends in CS probability are very different for breech and non-breech singletons, we focus exclusively on breech babies and do not consider non-breech births as controls, e.g., in a difference-in-differences design.

The fuzzy RD design identifies the average treatment effect locally at the cut-off as

$$E[Y_i(1) - Y_i(0)|complier, X_i = c] \tag{1}$$

Thus the fuzzy design is comparable to an instrumental variable approach (Angrist and Pischke, 2008; Imbens and Lemieux, 2008), i.e., we estimate a local average treatment effect (LATE) for complying mothers who change CS status because of the dissemination of the TBT results.

To validate our comparison of outcomes across the cut-off, we rely on the *local continuity assumption*, which states that individuals just below and just above the cut-off have similar potential outcomes in the absence of treatment. Furthermore, other characteristics than treatment status develop smoothly through the cut-off, i.e., we assume that treated and untreated individuals close to the cut-off differ only in their value of the forcing variable X and are otherwise comparable.

Although the focus on the locality is crucial for identification in the RD design, we have to extrapolate away from the cut-off in our estimations. However, moving farther away from the cut-off means that we are less likely to meet the criteria for a valid RD analysis. Consequently, we compare different specifications and carefully document the ways in which we constrain the estimation sample.

We use two-stage least squares to estimate the effect of CS for marginal breech babies. We cluster standard errors at the hospital level to allow for correlations across birth events in the same hospital. Our second stage equation is:

$$Y_{hi} = \alpha_2 + \beta_2 \times \hat{CS}_{hi} + f(forcing - c) + \delta_2 \times Z_{hi} + \gamma_h + \epsilon_{2hi} \tag{2}$$

where $\hat{CS}_{hi}$ is the predicted probability for CS of mother i in hospital h, $(forcing - c)$ is calender time in days (centered around the cut-off), Z_{hi} are mother and child-specific controls and ϵ_{2hi} is a random error term. γ_h is a hospital fixed effect that accounts for hospital-specific factors such as general hospital and physician quality. The key assumption is that $f()$ is a smooth and continuous function throughout the cut-off.[17]

Our first stage equation for CS_i—estimating the jump in treatment probability at the cut-off—accordingly is

$$CS_{hi} = \alpha_1 + \beta_1 \times c + g(forcing - c) + \delta_1 \times Z_{hi} + \gamma_h + \epsilon_{1hi} \tag{3}$$

Given that we have to estimate our regressions on data in a larger neighborhood of c, the choice of the function $f()$ (and $g()$) is crucial for our analysis. Applying data inspection and a regression-based test suggested in (Lee and Lemieux, 2010), we prefer a linear specification.[18] We also present alternative specifications that include second- and third-order polynomials. Additionally, we examine the sensitivity of our results by presenting estimates from local linear regressions for smaller data windows around the cut-off. Point estimates remain similar though much less precise for smaller windows.[19]

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[17] We estimate both our first and second stage with the same order polynomials.

[18] We conclude this based on a test suggested by (Lee and Lemieux, 2010): we introduce 30 day-bin dummies and test for their joint significance in our regression of outcomes on both the forcing variable and an indicator for post-TBT birth. Given that these bin dummies are not jointly significant, we conclude that a linear specifications fit our data well.

[19] We use a rectangular kernel that puts equal weight on all observations and amounts to estimating OLS in a small data window as suggested by, e.g., Lee and Lemieux (2010). Kernel choice does not alter our results. We experiment with different bandwidths, among them the rule of thumb bandwidth (RoT) suggested in Fan and Gijbels (1996) and tighter and larger bandwidths. We estimate the RoT bandwidth separately for each side of the cut-off and follow the procedure described in Fan and Gijbels (1996) and Lee and Lemieux (2009) for a rectangular kernel.

4. Data and summary statistics

We combine data from several Danish administrative registers. Our data set consists of all 403,003 live births from August 4, 1997, through April 4, 2004 (around 40 months before and after the TBT). We identify 15,683 live births that during pregnancy or at birth were diagnosed as breech (see appendix 10 for all ICD10 codes used in our analyses). We further restrict our breech sample in the following three steps: First, we exclude babies who were successfully turned around before the onset of labor (around 12 percent). Second, as OBs—both before and after the TBT—usually perform a CS for breech babies who have to be delivered prematurely, we exclude preterm births (before 37 weeks of gestation, around 10 percent).[20] Third, as there is no discontinuous change in the CS probability for first-time mothers, we exclude these mothers (58 percent) (see appendix table 8.3). Restricting this sample to individuals with non-missing outcome data, our final sample of breech babies consists of 4992 singleton live births at term with a higher parity than one.[21]

Our explanatory variable of interest is mode of delivery defined as either a CS or a completed vaginal delivery. A CS scheduled and performed within eight hours is labeled as an emergency CS, while all other types of CS are labelled elective. We pool both types of CS in our analysis for two reasons: First, our data on type of CS is poor (due to changing coding practice) and leaves a considerable percentage of CS's not uniquely characterized. Second, the TBT resulted in an increase in both elective and emergency CS during the period under consideration.[22]

We consider the following four outcomes in our analysis of child health. First, we use the APGAR score at five minutes, which evaluates infants' vitality immediately after birth on

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[20] We do not account for babies' congenital diseases or anomalies. However, for the RD analysis—as long as there is continuity in the neighborhood of c—the inclusion of babies with anomalies should have no effect on the results. Babies with congenital diseases are most likely delivered by a CS both before and after the TBT.

[21] Estimating all regressions on samples that do not introduce this last constrain, we find identical results for each outcome. Results are available on request.

[22] Both the probability of an elective and an emergency CS increased around the cut-off as shown in table 1. As there are no differences in requirements regarding medical staff present for the two types of CS, we assume that the quality of the two types of CS is comparable.

the basis of five criteria: infants' color, muscle tone, breathing, heart rate and responsiveness. The APGAR score ranges from 0 to 10. A number of studies have shown that a low APGAR score is correlated with future outcomes, such as cognitive ability, behavioral problems, and mortality (Almond, Chay and Lee, 2005; Diepeveen et al., 2013; Odd et al., 2008). We use a continuous APGAR measure in our main specification. While the economic literature has used both a continuous measure and various cut-offs (at 7 through 9) (Dubay, Kaestner and Waidmann, 1999; Almond, Chay and Lee, 2005; Almond, Currie and Simeonova, 2011; Rossin, 2011), in line with Hannah et al. (2000), we also use a score lower than 7 as an indicator for poor health.

Second, we construct a measure of serious neonatal morbidity (see appendix 10). While we cannot perfectly match the TBT measure with our administrative data, our measure includes a set of diagnoses that constitute a good proxy for serious neonatal problems related to the delivery.

Third, we examine the number of general practitioner (GP) visits from birth until age two. Fourth, to capture more severe health problems in early life, we construct an indicator for more than two overnight hospital stays before age three. For this measure, we disregard hospitalizations in connection with birth and exclude outpatient visits.[23] In the distribution of hospitalizations for breech births, our threshold value (>2 days) is equivalent to the fourth quartile before the TBT. In our estimation sample, we observe an infant mortality rate (in the first year of life) of 0.5 percent for breech babies. We do not consider this very rare outcome in the proceeding analysis.[24]

As the benefits of CS for the child can be outweighed by a potential higher risk for the mother, we also consider three indicators for maternal health. First, we define an indicator taking the value one for post-birth infections (see appendix 10). Second, we define an indicator taking the value one for the most frequent maternal post-birth complications related

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[23] An analysis for the number of outpatient visits does not show significant results and is available on request.

[24] With the indicated proportion of infant deaths we lack power in this analyis that yields very imprecise results that are available on request.

to the delivery itself (Danish National Board of Health, 2005*b*).[25] Third, we consider the length of maternal post-birth hospital stay.

Although control variables for mother and child characteristics should not matter in our RD design, controls can improve the precision of estimates and can help examine the validity of the RD analysis. We construct the following measures: birth weight (in grams) and sex for the child; mother's age at birth, immigrant status, educational level, and occupation (health professional); indicators for a set of maternal pregnancy related complications (e.g., diabetes, preeclampsia) (see appendix 10); and indicators for attempted and successful external cephalic versions of the baby.

Table 1 compares our sample of higher parity breech babies and mothers on both sides of the cut-off. CS rates increased considerably after TBT from a mean of 63 percent to a mean of 78 percent. After TBT, the table also indicates small decreases in the percentage of breech babies with a low APGAR score but no change in the probability of serious morbidity. In addition, for our GP contacts and hospitalization outcomes, the summary statistics show that the average number of GP contacts increases marginally while the probability of being hospitalized for more than three days decreases. This difference in means for the GP contacts and hospitalization measures could indicate substitution of hospital contacts with GP contacts. Comparing mothers' background characteristics before and after TBT, the table also shows trends in average age and education. For mothers' outcomes, the raw means show decreases in both the number of infections and post-birth complications. Also the average number of days in the hospital after birth decreases for all breech mothers (as for the general population of mothers) in the period.

While a naive comparison of means in Table1 shows significant differences in several means for pre- and post-TBT breech births, these changes in outcome and control variable means may simply reflect ongoing trends (e.g., in the data period hospitalization lengths decrease for all births, outpatient contacts become more important, maternal age at birth

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[25] As very few women die in Denmark in child birth and as we are constrained by the small sample size, we do not examine the effects of CS on maternal mortality.

increases for all births). Therefore, the next section turns to the graphical and regression analyses that exploit the TBT dissemination while taking these trends into account.

5. Results

5.1. Treatment

Zooming in on higher order breech babies around the cut-off, Figure 2 shows a significant jump in the probability of a CS. The figure shows both bin means for 40 non-overlapping bins of 30 days on each side of the cut-off and a linear fitted line.[26] As mentioned earlier, we find no discontinuous change in CS probability for first-time mothers (see appendix figure 8.3). Thus, in accordance with pre-TBT strict selection criteria for a vaginal birth, we find pre-existing and strong trends for first-time mothers with a baby in breech position. In contrast, for higher parity mothers, the CS probability was relatively low, and the TBT increased the CS rate significantly.

Table 2 presents the regression equivalent to Figure 2, namely, our first stage with alternative specifications.[27] After the TBT, breech babies are around 14 percentage points more likely to be born by CS. This result is robust across specifications that include different order polynomials and controls.[28] When we vary the size of the data window, the F-value presented in the table indicates that we need a little more than one year of data on both sides of the cut-off to have a strong instrument.

To interpret our results, we can characterize complying mothers who are more likely to have a CS due to the dissemination of the TBT (Angrist and Pischke, 2008; Doyle, 2008). Appendix figure 8.6 plots estimates for the post-TBT birth indicator across the maternal age

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[26] Our preferred bin width is 30 days, a bin size that represents the data well and secures enough observations per bin for us to avoid too much noisiness in the graphs. We present alternative data windows and bin widths in Appendix figures 8.4 and 8.5. They show that the jump persists with narrower bins (15 days) and smaller data windows (20 bins).

[27] For various bandwidths and using local linear regressions, we also estimate the size of the jump in the probability of CS. From a bandwidth of 180 days on each side of the cut-off, the estimate for the jump in treatment probability stabilizes between 14 and 15 percentage points. This jump is significant at the five percent level and robust to kernel choice (see table 8.2).

[28] The inclusion of control variables for child's sex, indicators for maternal age and educational group, and a set of maternal pregnancy complications does not significantly change the results. Estimates are available on request.

distribution. While we cannot reject that all first-stage coefficients are equal, a comparison of the point estimates suggests that mothers in both tails of the age distribution are more likely to be among compliers. This u-shaped selection of mothers into CS is in line with, first, the medical literature that suggest higher risk for poor pregnancy outcomes for both young and old mothers (Ohlsson and Shah, 2008), and, second, with doctors selecting those mothers more strictly into CS after the TBT.

5.2. Child and mother health outcomes

Figure 3 plots mean child health outcomes using a bin width of 30 days, a data window of 40 non-overlapping bins (months) on each side of the cut-off. The figure also includes a linear fitted line. The figure indicates that the TBT decreased the probability of a low APGAR score, whereas it shows only a marginal decrease in the probability of serious neonatal morbidity. Figure 3 shows a significant decrease in the average number of GP contacts after the cut-off, whereas for child hospitalizations until age three, the figure does not indicate a significant jump around the cut-off. Thus while the graphs indicate that breech babies experienced improvements not only in an immediate (birth) outcome but also in early childhood, as measured by an indicator for modest health problems (i.e., GP visits), the graphs for serious morbidity and hospitalization do not indicate strong and persistent effects.[29] Figure 4—which is parallel to Figure 3—shows that for breech mothers there is no indication of a discrete jump in the probability of experiencing two post-birth health problems, post-birth infections or a set of post-birth complications. Mothers' post-birth hospital increases marginally after the TBT.

Table 3 presents estimations for the effect of the TBT on the described outcomes (the reduced form results). Column 1 presents results without control variables and column 2 includes controls for maternal and child characteristics (see table notes), both specifications include a hospital fixed effect and cluster standard errors at the hospital level. For infant health, the table shows that the TBT dissemination increases the five minute APGAR score

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[29] We also examined alternative measures, such as hospital outpatient contacts and hospitalizations of different durations and at other ages (at birth and age five). Graphs for these outcomes are very similar to those in the table and are available on request.

with 0.08 points and reduces the probability of a low APGAR score (strictly smaller than 7) by 1 percentage point. This estimate is very large, given that 0.7 percent of the full pre-TBT sample have an APGAR score strictly below seven. To evaluate the size of this estimate, we compare the patterns in our data to the findings of the TBT. The TBT finds a relative risk ratio for having a low APGAR score at five minutes of 0.26. This score indicates that breech babies delivered by an elective CS are 74 percent (1-0.26) less likely to receive a low APGAR score than those delivered by vaginal breech birth, i.e. also the TBT identified large effects of CS on the APGAR score.[30]

Table 3 also shows that after the TBT, breech babies have on average 1.6 fewer GP contacts in their first two years of life. This change corresponds to a 10 percent decrease. In accordance with the graphical evidence, for other child outcomes estimates are small and very imprecisely estimated. For maternal outcomes, we find an increase in the length of post-birth hospital stay of around 0.3 days but small and insignificant effects for infections and post-birth complications.

Tables 4 and 5 present our IV results for child and maternal health outcomes, respectively. Columns 1 and 2 show our IV estimates for linear models, columns 3 and 4 include quadratic polynomials, columns 5 and 6 include cubic polynomials, and columns 7 and 8 show local linear regressions for smaller windows of data (see table notes). Columns 2, 4, and 6 include control variables, columns 1-6 include hospital fixed effects and cluster standard errors at the hospital level. Given that—for all outcomes—our estimates from the local linear regressions and our 2SLS estimates overall compare well, we conclude that our results are not driven by functional form assumptions.

As indicated in our graphs and the results presented this far, Table 4 shows that the marginal breech baby experiences a significant and large improvement in the APGAR score at five minutes of around 0.54-0.58 points. The estimates are similar in size and show—across

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[30] Constructing the comparison groups used in the TBT, we find a similar risk ratio of 0.21 [C.I. 0.08-0.52, p=0.000] to that of the TBT. Comparing all types of CS with completed vaginal breech births, we find a risk ratio of 0.33 [C.I. 0.16-0.66, p=0.001] equivalent to a 67 percent reduction in the probability of receiving a log APGAR score.

specifications—that children born by CS have a significantly higher score at this point. For our discrete measure of a low score, we find very large point estimates of around -0.07.[31]

We also find that CS decreases the number of GP contacts in the first two years of life by around 10-11 visits for the marginal child, i.e., a number that corresponds to a 66 percent decrease at the mean of the dependent variable. The estimate suggests that GP visits decrease to an average of around six visits, which roughly corresponds to the recommended number of visits for health check-ups for toddlers in Denmark. Given the sample mean for GP visits of 16.3 in the pre-TBT period, our estimate implies sample means of 12.23 and 23.23 visits for infants born by CS or naturally, respectively.[32]

As in Table 3, the effects on serious child morbidity and hospitalization are imprecisely estimated. While point estimates are large for morbidity (in accordance with our finding of a significant effect on the APGAR score), estimates for child hospitalizations are small and do as such not indicate longer-run benefits.[33]

To interpret our findings, we have to consider the context of a low neonatal morbidity country like Denmark. Even before the TBT, strict selection criteria for vaginal births existed for breech pregnancies. Reactions to the TBT led to the tightening of selection criteria and thus our "next-in-line" group of CS for breech pregnancies is relatively healthy and less likely to experience serious morbidity than the babies randomized in the TBT. Finally, for longer-run outcomes, we add to the TBT results and find that the initial health benefits for the marginal CS breeches (higher APGAR) do not appear to predict longer-run serious health problems (proxied by hospitalizations). Nonetheless, we find that the marginal CS baby benefits with respect to minor health problems in early childhood, measured as GP

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[31] Although not significant, the effects are of similar size for the probability of a low APGAR score at one minute. The lack of significance at one minute is most likely due to greater measurement error in this very early measure. At five minutes the APGAR score is more reliable and most likely a better indicator of general health at birth.

[32] We can compute the sample mean as the weighted means of CS and natural birth children. We solve: $16.3=0.63(X-11)+0.37X$

[33] We also consider number of outpatient visits and hospitalization measures immediately after birth and at age five. When considering these measures, we also find imprecisely estimated results, and the point estimates are smaller in absolute size. Results are available on request.

visits.

For maternal health, Table 5 show positive but imprecise coefficients for the probability of infections, and negative but imprecise coefficients for severe post-birth complications. These findings mirror the ITT results and the graphical evidence. CS is performed routinely and to detect effects for maternal post-birth complications we need larger samples. However, the marginal CS mother experiences an increase in post-birth hospitalization length of around 2 days. This effect points to the relevance of including maternal hospitalization length and its costs into the overall cost calculations.

5.3. Economic consequences

In this section, we investigate the economic consequences of moving marginal breech babies from a natural delivery to a CS. For this calculation we consider changed expenditures to the delivery of breech babies, maternal hospitalizations and children's GP visits. Using our estimates, sample proportions and simple sample means, we calculate pre-TBT overall costs to breech deliveries and the overall change in expenditure for marginal breech babies as a consequence of the TBT. Given that we have no means for the marginal group of breech babies, we relate the changes in costs for this group to the overall pre-TBT spending in relation to breech babies at term.

To define the price of procedures and maternal post-birth hospitalization, we use the Danish official 2012 price specification for medical procedures. These prices are detailed and contain prices for a breech vaginal delivery, an elective CS and various types of emergency CS by parity. As we cannot perfectly distinguish between elective and emergency CS, we average over the given prices for all types of CS. To test for the robustness of our results we also calculate the costs by only using the cheapest CS price, elective CS (which increased most). To define the average price per GP visit, we use information on fees for services to GPs (see details in Appendix 9).

Table 9.1 shows our cost calculation. The upper panel shows average costs for our pre-TBT period. The costs are related to mode of delivery, maternal hospitalization and GP visits for our sample of breech babies. We find that the direct pre-TBT costs related to breech deliveries in Denmark were 40,267,400 US dollars (which corresponds to an average of 15,662 US dollars per birth in our data period before the TBT).

The lower panel shows the changes in costs induced by the change of mode of delivery for marginal children after the TBT. For these estimates, we assume that in line with our first stage the CS rate increases by 14 percentage points, or 350 babies in our data period. Given our finding of an on average 2.2 day increase in maternal hospitalization and a decrease in GP visits of on average 10.6 visits for the marginal breech baby, we find that as a consequence of the TBT, medical expenses increased by 4 percent from the baseline level. If we calculate the cost of a CS by only considering the price of elective CS, the cost increase is 3 percent compared to the average level of expenditure to breech deliveries in the pre-TBT period.

Our analysis has shown that CS has health benefits for the marginal breech children. We show here that these benefits come at a price. However, given our result that CS for marginal breech babies at term improves health measures that are hard to quantify and given that we cannot investigate all these health consequences for mothers and children (such as potential longer-run positive consequences of an improved APGAR score), we conclude that our finding of increased costs may be outweighed by improved child health and may lower costs to medical care later on.

5.4. Robustness checks

This section discusses potential threats to our identification strategy, such as self-selection of mothers into CS and concurrent changes that could confound our analysis. We also present graphs for mothers' background characteristics and placebo reforms and groups. Jumps in these graphs, if present, could indicate that the RD design is not valid. All figures appear in the online appendix.

First, we examine whether the prevalence of the breech diagnose varies on both sides of our cut-off. Plotting the density of our forcing variable over a number of bins around the cut-off date, we find that the percentage of breech babies per bin remains stable throughout the cut-off. Thus we have no indication that diagnostic efforts changed around the cut-off, or that mothers or OBs manipulate the date of birth around the TBT dissemination—an event we find highly unlikely to begin with (appendix figure 8.8).

Second, for our identification strategy to be valid, the increase in CS rates should not be driven by maternal selection into the treatment. Earlier studies on medical procedures that focus on patients' characteristics find that patients react strongly to newly available information. While our application concentrates on changes on the part of OBs, factors such as the level of maternal education could be an important determinant of changes in CS probability. If—as suggested in models of health production—well-educated individuals are better at processing and acting on information, we would expect highly-educated women to react more strongly to the TBT dissemination (Anderberg, Chevalier and Wadsworth, 2011; Price and Simon, 2009). Nonetheless, we find no support for the suggestion that mothers with higher bargaining power drive the increase in CS probability (appendix figure 8.9).[34]

Another important indicator of bargaining power is mothers' medical expertise. We find that mothers trained in health professions (midwives, physicians, and nurses) had a marginally higher level of CS before the TBT and a smaller jump of CS probability after the TBT (appendix figure 8.10). This smaller jump in CS probability supports the idea that these mothers have greater bargaining power and thus higher self-selection into the preferred mode of delivery, i.e., these mothers seem generally less likely to comply with OBs' recommendations. However, this smaller jump also indicates that this selection effect existed already before the TBT and therefore cannot drive our results.

Examining selection into treatment on the basis of other maternal characteristics, we find that the jump in CS probability is not driven by an increased percentage of mothers with a previous CS in the sample (appendix figure 8.11). Additionally, the percentage of mothers who change their hospital between the first trimester and birth remains stable and therefore does not indicate that mothers' change of hospital (or correlated hospital differences that we do not observe) drives our results (appendix figure 8.12). Moreover, plotting measures for maternal and child background characteristics (age at birth, immigrant status, and child

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[34] We do not present confident bands for expositional clarity. The two groups of mothers are indistinguishable in their pre- and post-TBT CS means.

gender) we see no jump at the cut-off date (appendix figure 8.13). Regressions equivalent to this figure yield the same result and are available on request.

Third, we also perform two falsification tests by graphing our data in two alternative ways: First, we use a set of placebo cut-offs (among them January 1, 1999) (appendix figure 8.14). Second, we analyze a placebo group of pregnancies with high CS probability, i.e., mothers with preeclampsia (appendix figure 8.15). For both tests–and regressions equivalent to the graphs–we find no indication of either placebo cut-offs affecting the CS probability of breech babies or of women with preeclampsia being affected by the TBT cut-off.

Fourth, we examine the existence of other relevant technological changes that could happen concurrently with the TBT. Prime candidates for such parallel changes in technology are new diagnostic efforts to discover breech babies before labor and a higher success rate for attempted external cephalic versions. We find only a small and insignificant increase in the percentage of breech babies diagnosed pre-labor after the cut-off (appendix figure 8.16). For the percentage of breech babies with an attempted or successful external cephalic version (appendix figures 8.17 and 8.18), we find no discontinuous jump at the cut-off. Thus these findings do not support the idea that other parallel changes in this technology coincide with the increase of CS use for breech babies.[35]

6. Conclusion

To examine the health effects of CS on the marginal mother and child, this paper exploits exogenous variation in CS probability for a well-defined subgroup of pregnancies—breech pregnancies at term. For the marginal baby, we find that the CS improves the five minute APGAR score and results in fewer GP visits in the first two years of life. Given that some doubt remains as to whether the APGAR score is a good predictor for future health and that we fail to identify significant effects on a strong indicator of longer-run child health–hospitalizations until age three–we conclude that the longer-run health effects of CS for breech babies are modest.

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[35] Nor do changes occur in the use of ultrasound in the last trimester.

For the marginal mother we find that post-birth hospitalizations increase in length, but we lack precision in our estimates for risk of infection and post-birth complications. Although the RD design offers a strong evaluation method with "local randomization" this design requires more data than an RCT to detect similar effects at a particular confidence level. Thus part of our imprecise findings for maternal health outcomes may be due to power issues.

Our results suggest that supply-side factors, such as newly available information for the physicians, have a direct and strong effect on medical procedures, in the case of CS with some spillovers to patient health. This result is in contrast to the recent public debate on maternal requests for CS driving the increase in CS use. Our results also suggest that high levels of CS for breech babies–as present in the U.S. already before the TBT dissemination–come with some health benefits for relatively health breech babies.

While we cannot determine the channels through which the TBT increased CS use for breech babies—physicians' preferences, liability concerns or peer effects—we can analyze the direct economic consequences and resulting policy implications in Denmark. We find that direct costs to the medical system for breech deliveries increased with 3-4 percent of the pre-TBT average expenditures, mainly because of increased post-birth hospitalization of marginal mothers. Thus in Denmark and similar countries (with similar price structure and health profile), an elective CS for higher parity breech babies may not the cheapest option in the short run. However, we see evidence that it is the procedure with the lowest risk for the marginal baby. Moreover, because the long-run consequences of an improved APGAR score are unknown, short-run estimates may overstate the increase in costs. Similarly, our focus on higher order babies has prevented us from studying other important health consequences for mothers, such as potential health risks in consecutive pregnancies. Thus further research is warranted for shedding light on the total costs and benefits of CS for breech pregnancies.

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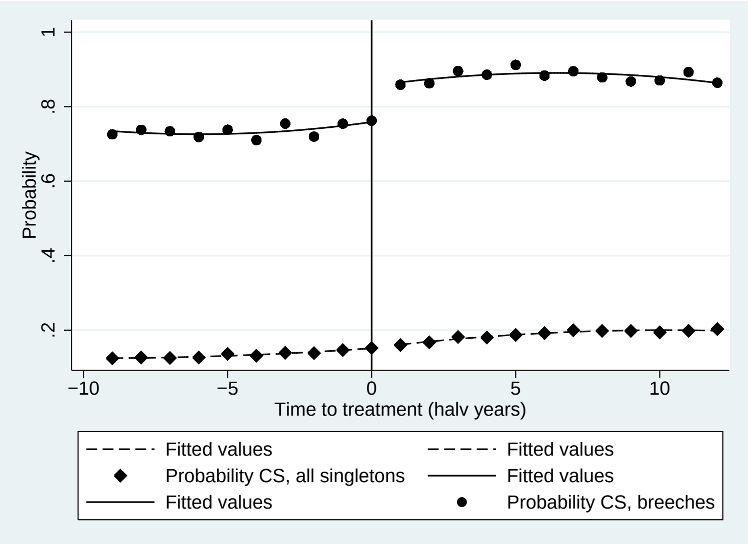
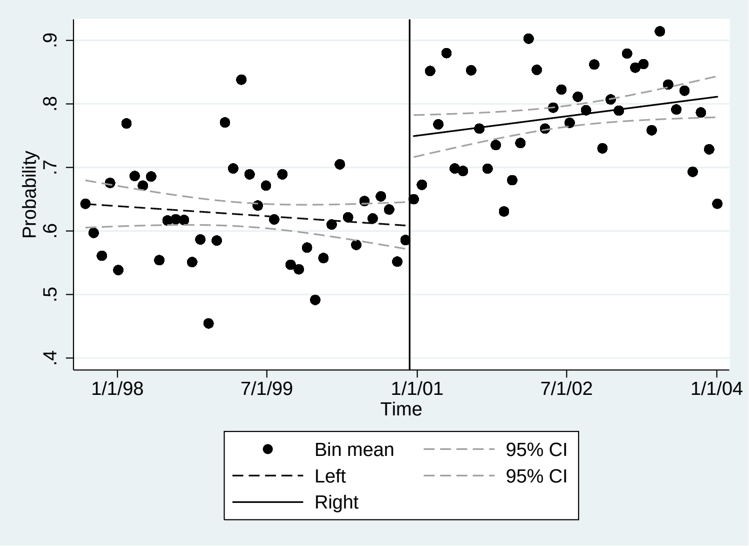
7. Tables and Figures

Figure 1: CS rate for all non-breech and breech pregnancies, 1996-2006



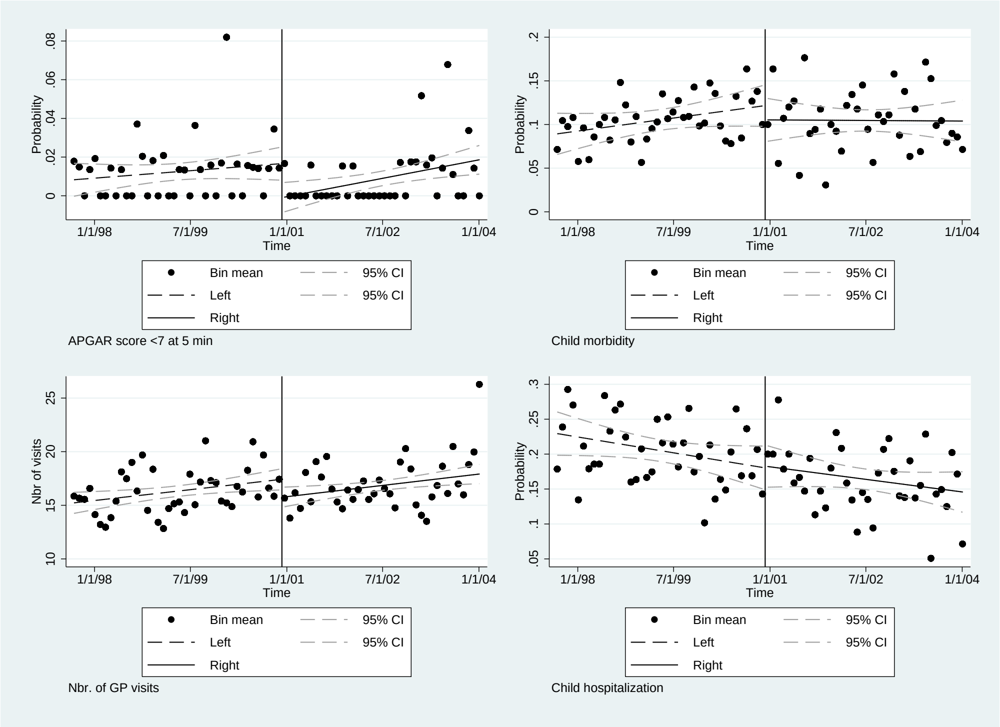
Notes: The plot shows the average probability of a CS per half-year. The vertical line is the date for the Danish dissemination of the TBT results. The sample includes all singleton births irrespective of parity.

Figure 2: CS rate for breech pregnancies at term with parity>1



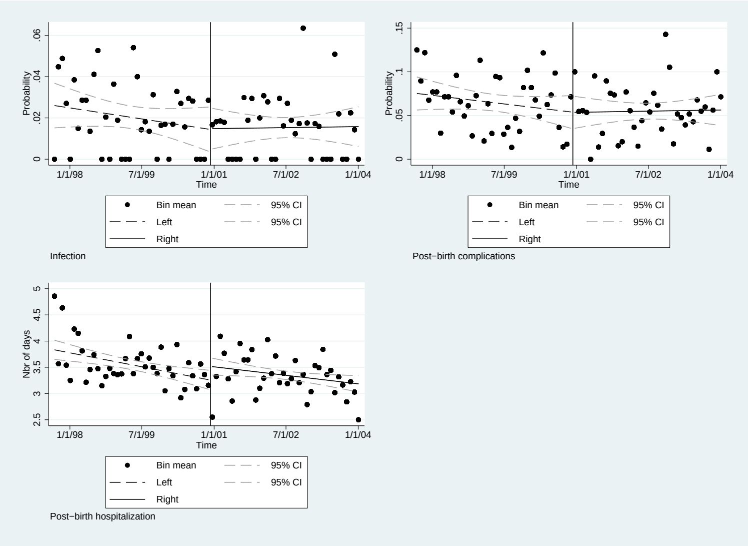
Notes: Each dot represents the average probability of a CS in a 30-day bin. The vertical line is the date for the Danish dissemination of the TBT and the figure plots 40 bins on each side of this cut-off.

Figure 3: Child health outcomes for breech babies at term with parity>1



Notes: In each graph, each dot defines the average for the outcome variable in a 30-day window (e.g. the probability of a APGAR score<=7). The vertical line is at the date for the Danish dissemination of the TBT and the figure plots 40 bins on each side of this cut-off. The graph in the upper left corner shows results for the APGAR score<=7, the graph in the upper right corner shows results for the probability of serious morbidity, the graph in the lower left corner shows results for the number of GP visits in the two first year of life, and the graph in the lower right corner shows results for the probability of more than three hospital overnight stays in the first three year of life (equivalent to the fourth quartile in the hospitalization distribution).

Figure 4: Maternal health outcomes for mothers with breech babies at term with parity>1



Notes: In each graph, each dot represents the average outcome variable in a 30-day window. The vertical line is at the date for the Danish dissemination of the TBT and the figure plots 40 bins on each side of this cut-off. The graph on the left-hand side shows results for the probability of post-birth infections and the graph on the right-hand side shows results for the probability of post-birth complications.

Table 1: Summary statistics for breech babies at term with parity>1, before and after the TBT

	Before TBT	*After TBT*
No. of obs.	2571	2421
Child and maternal outcomes		
APGAR 5, cont.	9.870	9.908
	(0.606)	(0.483)
APGAR<=7 at 5 min	0.012	0.009
APGAR<7 at 5 min	0.007	0.005
Death in first year	0.005	0.005
Serious morbidity, child	0.105	0.105
GP visits in first 2 years	16.336	16.853
	(12.786)	(11.467)
3+ days hospitalized in first 3 years	0.205	0.164
Mom: Post-birth complications, mother	0.065	0.055
Mom: Infection	0.021	0.015
Mom: Post birth hosp.	3.550	3.347
	(2.398)	(2.005)
Caesarean section		
CS	0.625	0.781
Elective CS	0.406	0.542
Emergency CS	0.158	0.199
CS, unknown type	0.065	0.047
Observable characteristics		
Birth weight	3450.973	3465.939
	(541.185)	(514.878)
Male child	0.475	0.475
Att. external cephalic version	0.226	0.263
Pregnancy complications	0.320	0.315
Pre-eclampsia	0.035	0.028
Diabetes	0.014	0.018
Mom's age	31.094	31.498
	(4.371)	(4.510)
Mom, immigrant	0.094	0.121
Mom/dad, married/cohab	0.917	0.914
Mom col/uni education	0.289	0.337
Mom high school education	0.755	0.770
Mom, employed	0.656	0.621

Continued on the next page.

Table 1 *continued.*

	Before TBT	After TBT
Mom, doc/midwife	0.007	0.006
Mom, doc/midwife/nurse	0.051	0.056
Mom, healtcare edu	0.075	0.088

Notes: The table shows means and standard deviations (in parenthesis) for the outcome variables and a set of background variables. The samples are singleton breech births at term with parity>1 born either before the cut-off (August 4, 1997-December 3, 2000) or after the cut-off (December 4,2000-April 4, 2004).

Table 2: First stage: The effect of the TBT indicator on CS probability for different model specifications

	Locallinear	Linear	Quadratic	Cubic
Treated	0.125***	0.145***	0.142***	0.119***
	(0.034)	(0.031)	(0.031)	(0.037)
N	1523	4992	4992	4992
F-value	13.678	21.637	21.339	10.432

Notes:. The table shows coefficients and clustered standard errors in parenthesis (hospital level) for four different model specifications. Column one shows the estimate for the treatment indicator in a linear regression that uses only one year of data on each side of the cut-off. Columns two to four show estimates from specifications that use the full data window and a linear, quadratic or a cubic functional form, respectively. All models include a hospital fixed effect. ***significant at the 1 percent level, **significant at the 5 percent level *significant at the 10 percent level

Table 3: The effect of the TBT indicator on child and mother health, breech babies at term with parity>1 (ITT results)

Outcome measure	*Linear*	*Linear, control*
Death in first year	0.003	0.003
	(0.002)	(0.002)
APGAR 5, cont.	0.079***	0.078***
	(0.025)	(0.025)
APGAR<7 at 5 min	-0.010***	-0.010***
	(0.003)	(0.003)
APGAR<=7 at 5 min	-0.017***	-0.017***
	(0.006)	(0.006)
Serious morbidity, child	-0.021	-0.020
	(0.013)	(0.013)
3+ days hospitalized in first 3 years	0.001	0.004
	(0.029)	(0.029)
GP visits in first 2 years	-1.651***	-1.568**
	(0.604)	(0.597)
Post-birth complications, mother	-0.001	-0.001
	(0.013)	(0.013)
Infection	0.001	0.001
	(0.006)	(0.006)
Mom: post birth hosp.	0.293**	0.318**
	(0.133)	(0.133)
N	4992	4992

Notes: The table shows the effect of the TBT indicator on child and maternal health. Each cell shows the estimate and clustered standard error for separate regressions. The first column is based on a linear model specification only including the forcing variable. The second column presents a linear model specification that include additional controls for male child, for maternal age above 31, for maternal college/university degree, and for maternal pregnancy complications (diabetes, preeclampsia, and other). All models include a hospital fixed effect. ***significant at the 1 percent level, **significant at the 5 percent level *significant at the 10 percent level

Table 4: The Effect of CS on child health

Outcome	*(1)* *lin.*	*(2)* *lin. contr.*	*(3)* *quadr.*	*(4)* *quadr. contr.*	*(5)* *cubic*	*(6)* *cubic contr.*	*(7)* *local*	*(8)* *1 yr*
APGAR 5, cont.	0.546***	0.531***	0.579***	0.564***	0.484	0.459	0.592	0.397
	(0.198)	(0.192)	(0.201)	(0.195)	(0.415)	(0.400)	(0.505)	(0.450)
apgar<7 at 5 min	-0.072***	-0.071***	-0.075***	-0.074***	-0.071	-0.067	-0.114	-0.068
	(0.025)	(0.024)	(0.025)	(0.024)	(0.054)	(0.052)	(0.071)	(0.062)
Serious morbidity, child	-0.145	-0.139	-0.140	-0.133	-0.168	-0.167	-0.044	-0.038
	(0.097)	(0.095)	(0.096)	(0.094)	(0.134)	(0.132)	(0.270)	(0.236)
GP visits in first 2 years	-11.401**	-10.644**	-11.680**	-10.870**	-10.614	-11.177	-9.150	-15.246
	(4.933)	(4.861)	(5.135)	(5.059)	(8.996)	(8.828)	(12.271)	(11.605)
3+ days hospitalized, 3 yrs	0.010	0.026	0.007	0.024	0.158	0.147	0.061	0.225
	(0.195)	(0.191)	(0.201)	(0.198)	(0.241)	(0.237)	(0.340)	(0.301)
N	4992	4992	4992	4992	4992	4992	1865	1523

Notes: Each cell shows the coefficients of a separate regression for the effect of CS on child and maternal health. Columns one and two are based on a linear model without and with control variables. Columns three and four show results for a quadratic model specification, columns five and six for a cubic model specification. Results in columns one through six are based on the full sample (80 months). Columns 7 and 8 present the results of local linear regressions using a rectangular kernel and the rule of thumb bandwidth (RoT) suggested by Fan and Gijbels (1996), and for a sample with a 12 months data window before and after the TBT. We use the outcome APGAR<=7 at 5 minute to calculate the RoT bandwidth and use the same bandwidth on both sides of the cut-off (447 days). Controls are indicator variables for male child, for maternal age<31, for maternal college or university degree, and for maternal pregnancy complications. Columns 1-6 include a hospital fixed effect and report clustered standard errors. ***significant at the 1 percent level, **significant at the 5 percent level *significant at the 10 percent level

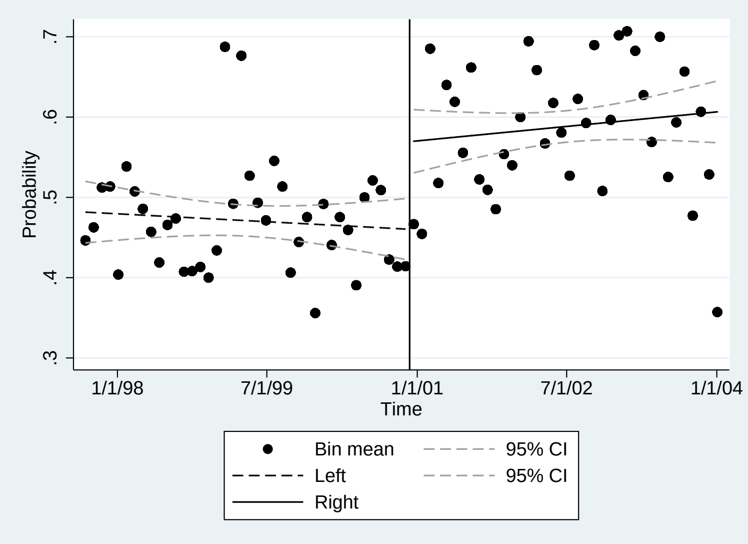
Table 5: The Effect of CS on maternal health

Outcome	*(1)* *lin.*	*(2)* *lin. contr.*	*(3)* *quadr.*	*(4)* *quadr. contr.*	*(5)* *cubic*	*(6)* *cubic contr.*	*(7)* *local*	*(8)* *1 yr*
Infection	0.010	0.008	0.006	0.004	-0.042	-0.044	-0.067	0.007
	(0.044)	(0.042)	(0.044)	(0.043)	(0.071)	(0.070)	(0.111)	(0.092)
Post-birth complications, mother	-0.009	-0.009	-0.018	-0.019	-0.131	-0.132	0.035	0.189
	(0.085)	(0.084)	(0.086)	(0.085)	(0.161)	(0.158)	(0.200)	(0.194)
Mom: post birth hosp.	2.022**	2.156***	1.982**	2.117***	-0.170	0.061	0.334	0.038
	(0.795)	(0.792)	(0.807)	(0.805)	(1.670)	(1.530)	(1.808)	(1.641)
N	4992	4992	4992	4992	4992	4992	1865	1523

Notes: See noted for table 4. ***significant at the 1 percent level, **significant at the 5 percent level *significant at the 10 percent level

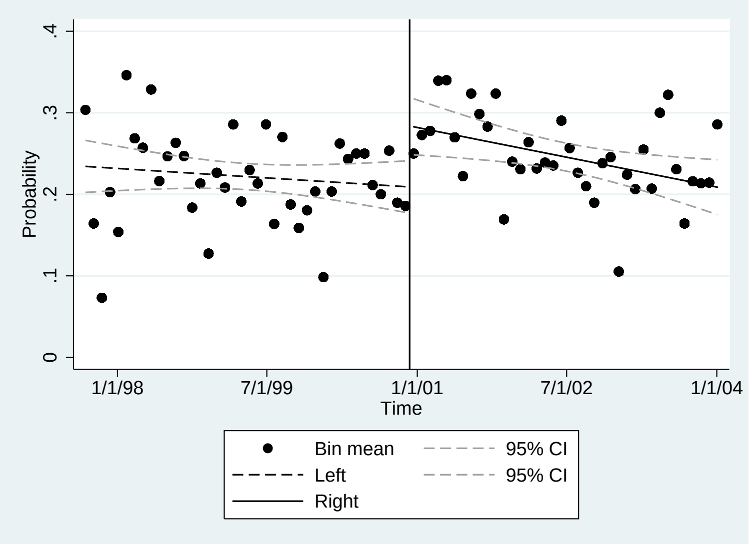
8. Online Appendix

Figure 8.1: CS rate for higher-parity breech pregnancies, elective and undefined CS



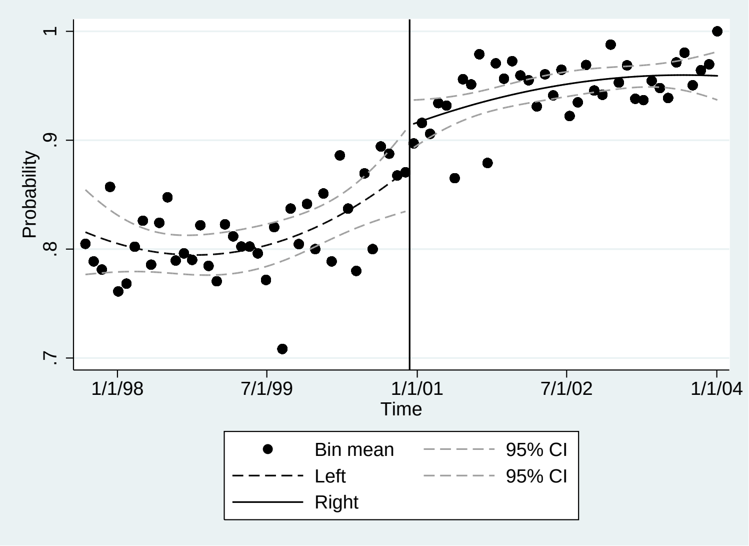
Notes: Each dot shows the average probability of a CS in a 30-day bin. The vertical line is at the date for the Danish dissemination of the TBT and the figure plots 40 bins on each side of this cut-off.

Figure 8.2: CS rate for higher-parity breech pregnancies, emergency and undefined CS



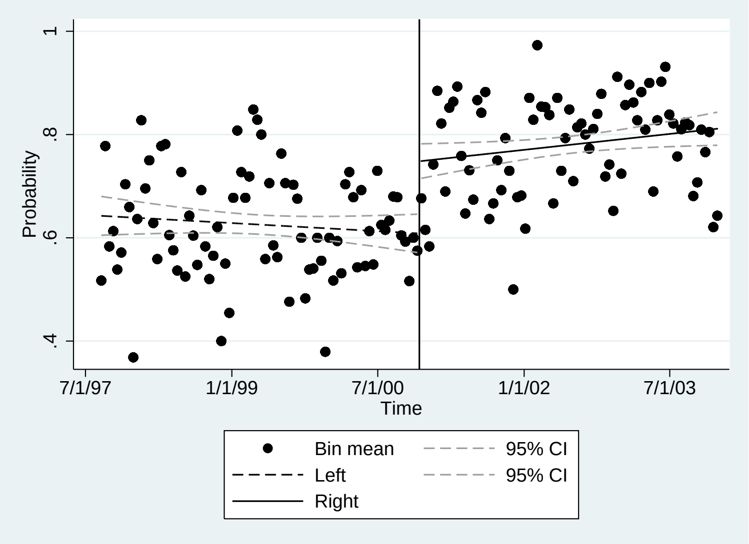
Notes: Each dot shows the average probability of a CS in a 30-day bin. The vertical line is at the date for the Danish dissemination of the TBT and the figure plots 40 bins on each side of this cut-off.

Figure 8.3: CS rate for breech pregnancies at term with parity 1



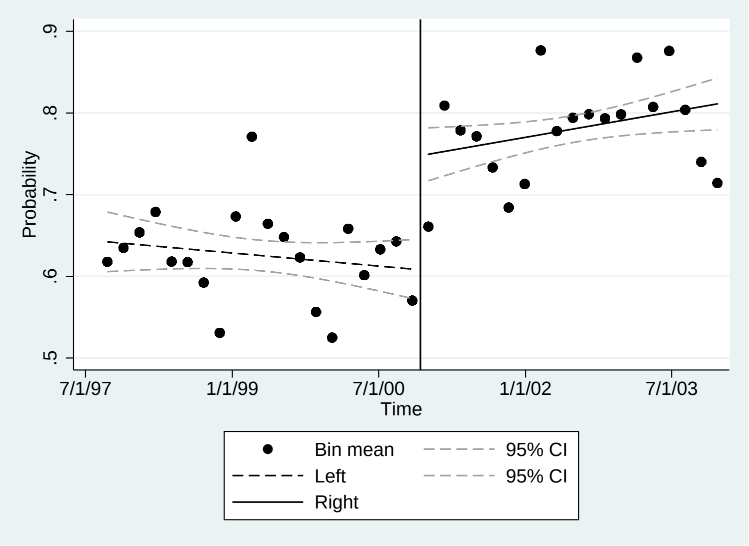
Notes: Each dot shows the average probability of a CS in a 30-day bin. The vertical line is at the date for the Danish dissemination of the TBT and the figure plots 40 bins on each side of this cut-off.

Figure 8.4: CS rate for breech babies at term with parity>1, smaller bins



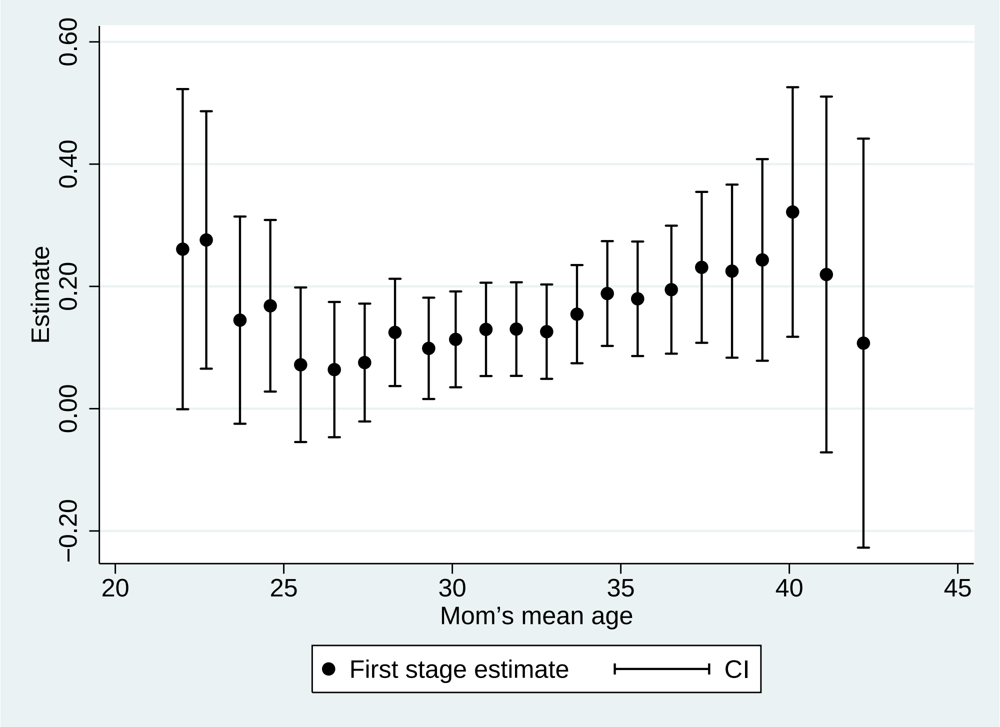
*Notes:*Each dot shows the average probability of a CS in a 15-day bin. The vertical line is at the date for the Danish dissemination of the TBT and the figure plots 80 bins on each side of this cut-off.

Figure 8.5: CS rate for breech babies at term with parity>1, narrow data window



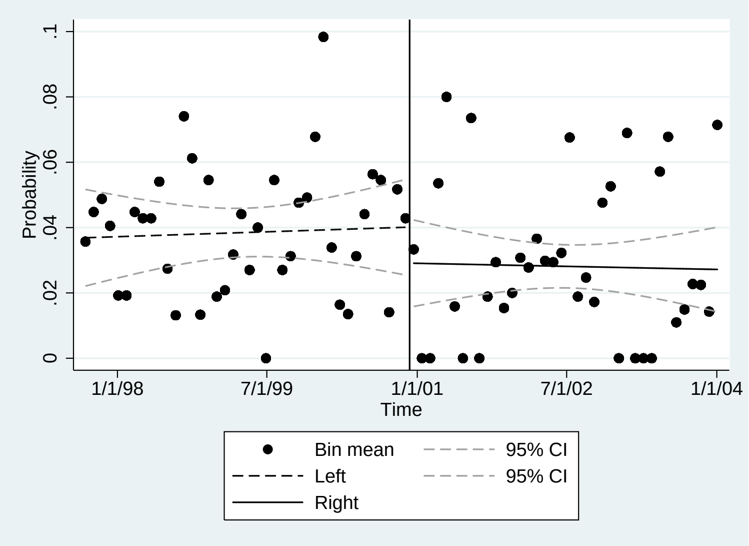
Notes: Each dot shows the average probability of a CS in a 30-day bin. The vertical line is at the date for the Danish dissemination of the TBT and the figure plots 20 bins on each side of this cut-off.

Figure 8.6: First stage for different maternal ages, 10-year moving data window



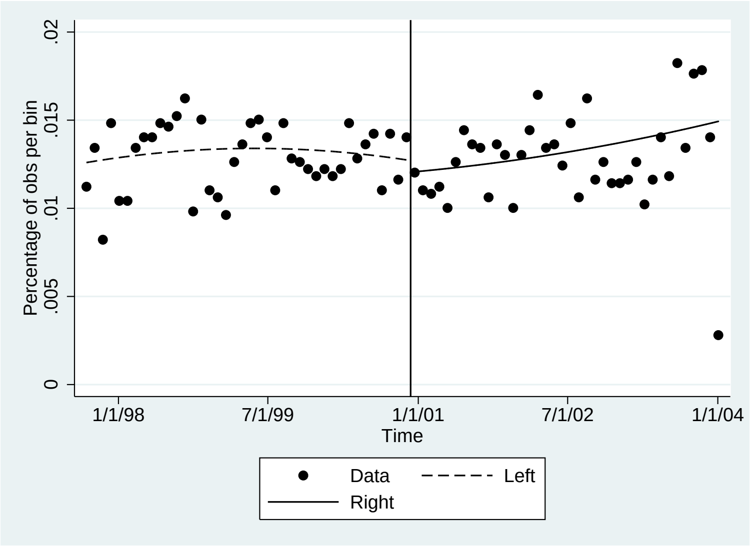
Notes: The figure plots the effect of the TBT indicator on CS probability by maternal age. The figure shows point estimates and the 95 percent confidence intervals for regressions using a moving 10-year age interval. These first stage regressions include controls for distance to cut-off (forcing variable), and indicators for maternal pregnancy complications, high educational level (college), and gender.

Figure 8.7: Probability of APGAR score<=7 at 1 min for breech babies at term with parity>1



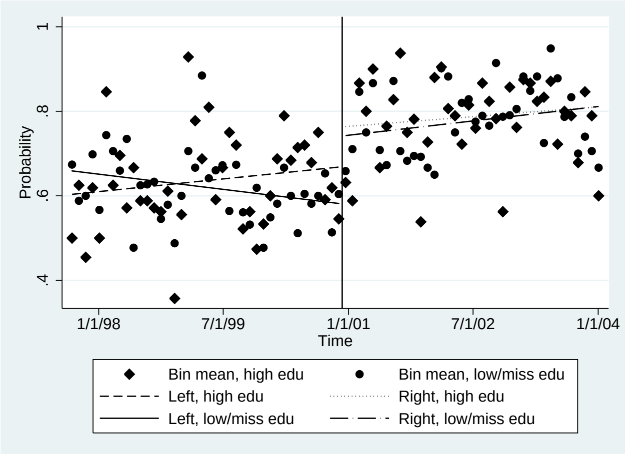
Notes: Each bin dot shows the average probability of APGAR score<=7 at 1 min. in a 30-day bin. The vertical line is at the date for the Danish dissemination of the TBT and the figure plots 40 bins on each side of this cut-off.

Figure 8.8: Density of the forcing variable



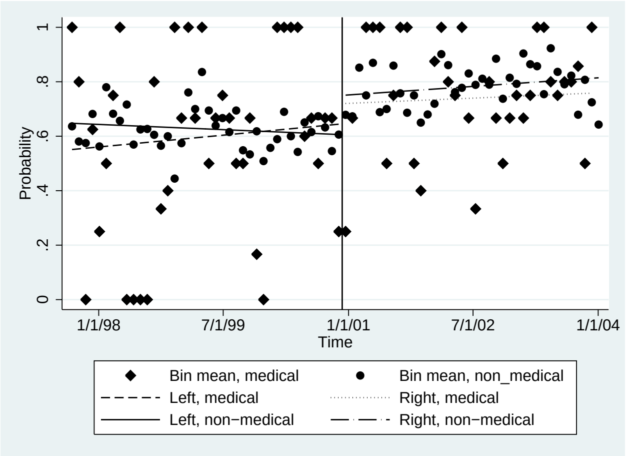
Notes: Each dot shows the percentage of observations of the sample in a 30-day bin. The vertical line is at the date for the Danish dissemination of the TBT and the figure plots 40 bins on each side of this cut-off.

Figure 8.9: CS rate for breech babies at term with parity>1 by maternal education (mothers with university degree vs. all other mothers)



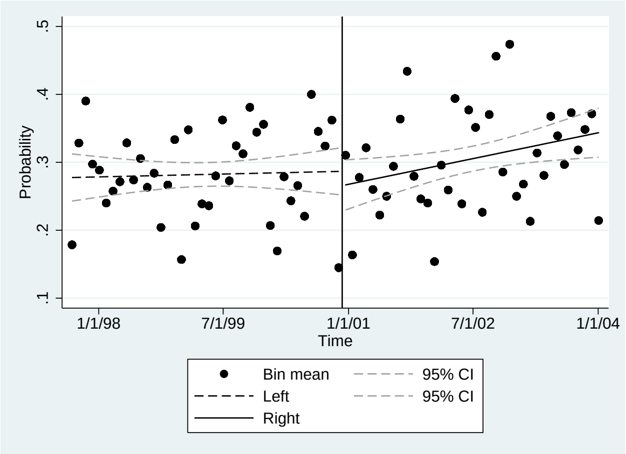
Notes: Each dot shows the average probability of a CS in a 30-day window. The vertical line is at the date for the Danish dissemination of the TBT and the figure plots 40 bins on each side of this cut-off.

Figure 8.10: CS rate for breech babies at term with parity>1, by maternal profession (medical profession vs. all other mothers)



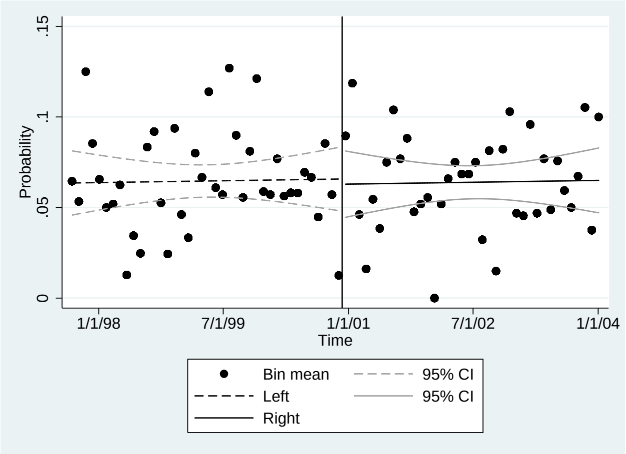
Notes: The indicator for medical profession includes physicians, midwifes and nurses. Each dot shows the average probability of a CS in a 30-day window. The vertical line is at the date for the Danish dissemination of the TBT and the figure plots 40 bins on each side of this cut-off.

Figure 8.11: Probability for breech mothers of having a previous CS



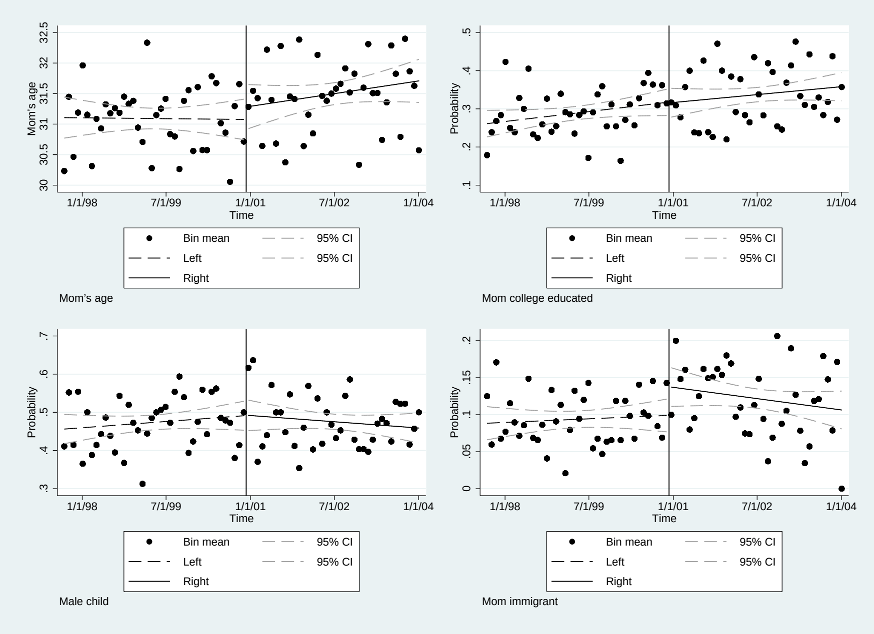
Notes: Each dot shows the share of breech mothers with a CS in a previous pregnancy in a 30-day bin. The vertical line is at the date for the Danish dissemination of the TBT and the figure plots 40 bins on each side of this cut-off.

Figure 8.12: The probability of breech mothers changing hospital



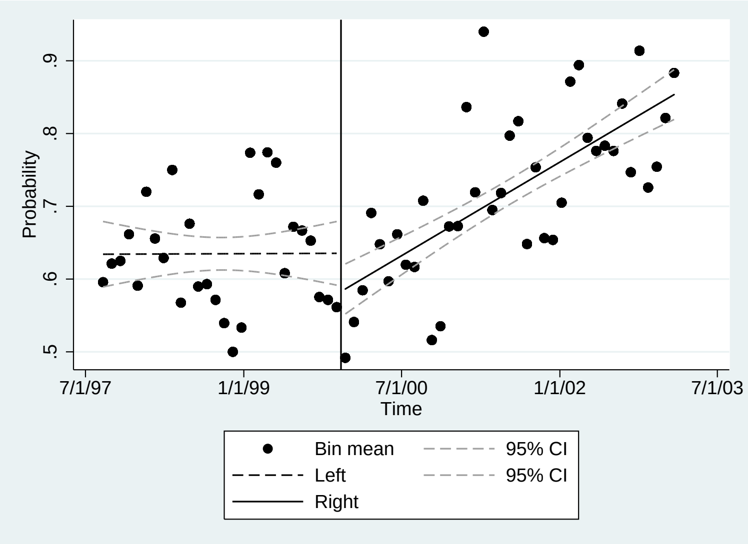
Notes: A change in hospital is defined as mothers observed at one hospital for their first pregnancy visit and another hospital for the birth of their child. The sample consists of mothers with breech babies at term with parity>1. Each dot shows the average probability of a CS in a 30-day bin. The vertical line is at the date for the Danish dissemination of the TBT and the figure plots 40 bins on each side of this cut-off.

Figure 8.13: Test for jump in maternal characteristics



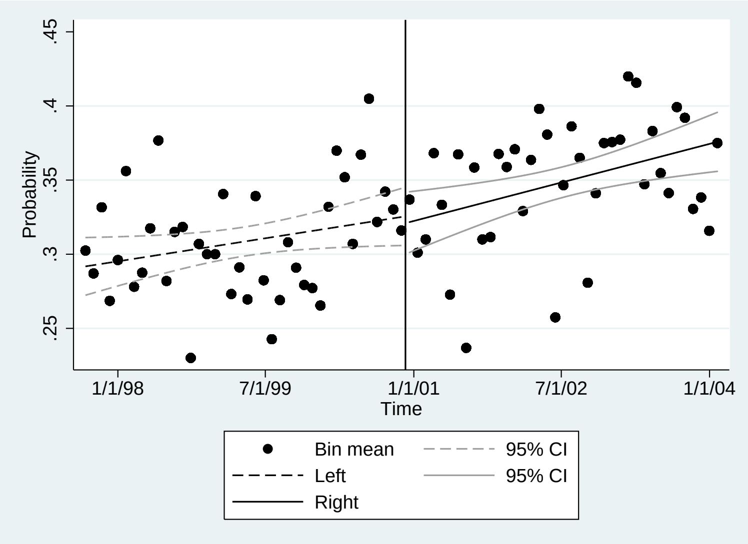
Notes: The sample includes mothers with breech babies at term with parity>1. Each dot shows the average probability of a CS in a 30-day bin. The vertical line is at the date for the Danish dissemination of the TBT and the figure plots 40 bins on each side of this cut-off.

Figure 8.14: CS rate for breech babies at term with parity>1 using December 4, 1999 as a placebo cut-off



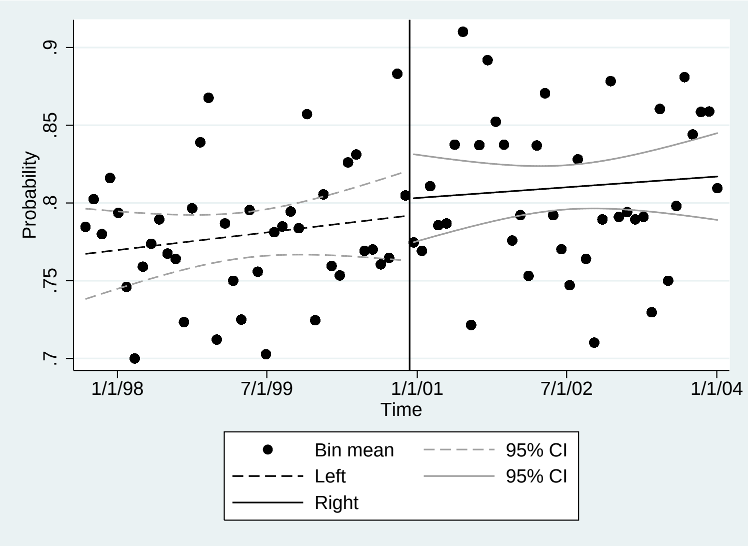
Notes: Each dot shows the average probability of a CS in a 30-day bin. The vertical line is at December 4,1999 and the figure plots 40 bins on each side of this cut-off.

Figure 8.15: CS rate for pregnancies with pre-eclampsia



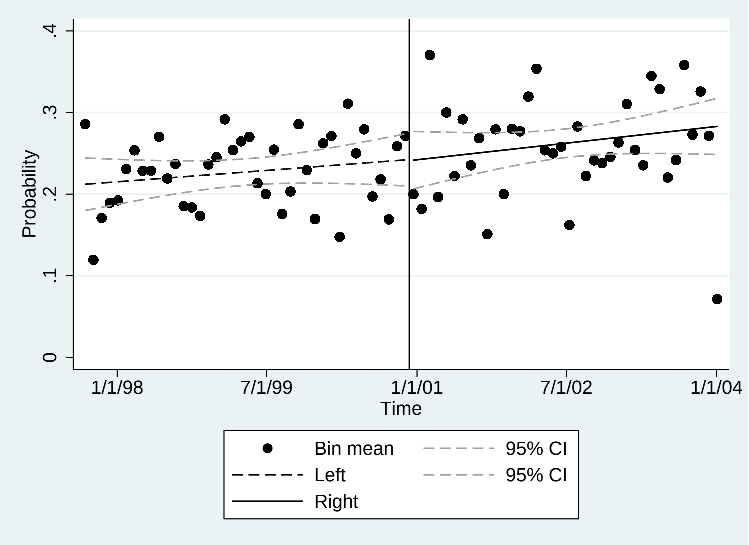
Notes: Each dot shows the average probability of a CS in a 30-day bin. The vertical line is at the date for the Danish dissemination of the TBT and the figure plots 40 bins on each side of this cut-off.

Figure 8.16: The probability of diagnosing breech before labor



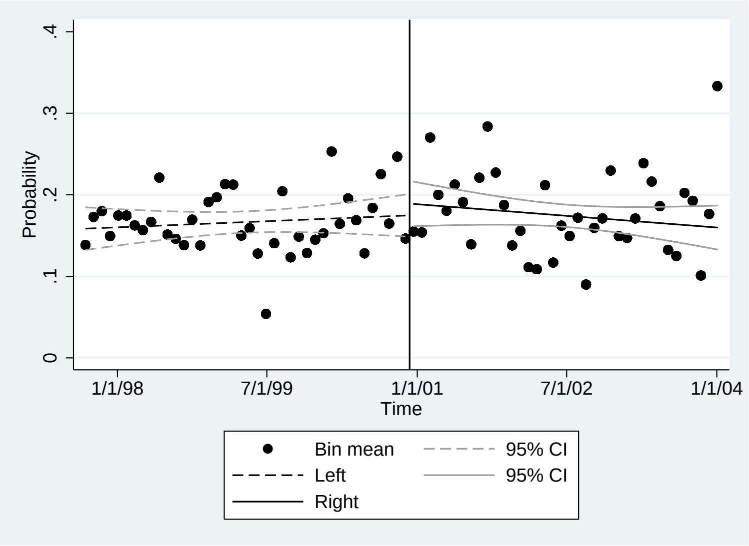
Notes: The dots show the probability of diagnosing breech pregnancy at least one day before birth in 30-day bins around the cut-off. The sample includes mothers with breech babies at term with parity>1. Each bin shows the average probability of diagnosing breech in a 30-day window. The vertical line is at the date for the Danish dissemination of the TBT and the figure plots 40 bins on each side of this cut-off.

Figure 8.17: Probability of an attempted or successful external cephalic version



Notes: The sample includes mothers with breech babies at term with parity>1. Each dot shows the probability of an attempted or successful version of the baby in 30-day bins around the cut-off. The vertical line is at the date for the Danish dissemination of the TBT and the figure plots 40 bins on each side of this cut-off.

Figure 8.18: The probability of a successful external cephalic version



Notes: The sample includes mothers with breech babies at term with parity>1. Each dot shows the probability of a successful version of the baby in 30-day bins around the cut-off. The vertical line is at the date for the Danish dissemination of the TBT and the figure plots 40 bins on each side of this cut-off.

Table 8.1: Summary statistics for the sample of breech and non-breech babies, means and standard deviations.

	Non-breech	*Breech*
No. of obs.	205913	4992
APGAR 5, cont.	9.906	9.888
	(0.501)	(0.550)
APGAR<=7 at 5 min	0.008	0.011
APGAR<7 at 5 min	0.004	0.006
Serious morbidity	0.070	0.105
Death in first year	0.002	0.005
GP visits in first 2 years	16.062	16.587
	(11.268)	(12.166)
3+ days hospitalized in first 4 years	0.154	0.185
Mom: post birth hosp.	2.062	3.451
	(1.913)	(2.218)
Mom: Post-birth complications, mother	0.054	0.060
Mom: Infection	0.007	0.018
CS	0.113	0.701
Elective CS	0.061	0.472
Emergency CS	0.042	0.177
CS, unknown type	0.011	0.056
Birth weight	3656.541	3458.231
	(503.845)	(528.590)
Male child	0.510	0.475
Att. external cephalic version	0.011	0.244
Pregnancy complications	0.237	0.318
Pre-eclampsia	0.028	0.031
Diabetes	0.015	0.016
Mom's age	30.915	31.290
	(4.376)	(4.443)
Mom, immigrant	0.131	0.107
Mom/dad, married/cohab	0.912	0.915
Mom col/uni education	0.328	0.313
Mom highschool education	0.763	0.762
Mom, employed	0.636	0.639
Mom, doc/midwife	0.008	0.007
Mom, doc/midwife/nurse	0.058	0.053
Mom, healtcare edu	0.089	0.081

Notes: The table shows means and standard deviations (in parenthesis) for the outcome variables and a set of background variables. The samples are singleton births at term with parity>1 born either before the cut-off (August 4, 1997-December 3, 2000) or after the cut-off (December 4,2000-April 4, 2004).

Table 8.2: Local linear regression estimates for the jump in the probability of having a CS for various bandwidths.

Estimate of jump, bw 15	0.025
	(0.237)
Estimate of jump, bw 30	0.208
	(0.162)
Estimate of jump, bw 60	0.128
	(0.122)
Estimate of jump, bw 90	0.097
	(0.096)
Estimate of jump, bw 120	0.121
	(0.081)
Estimate of jump, bw 150	0.092
	(0.074)
Estimate of jump, bw 180	0.140*
	(0.072)
Estimate of jump, bw 210	0.149**
	(0.067)
Estimate of jump, bw 240	0.130**
	(0.057)
Estimate of jump, bw 270	0.147**
	(0.059)
Estimate of jump, bw 300	0.150***
	(0.054)
Estimate of jump, bw 330	0.140***
	(0.053)
Estimate of jump, bw 360	0.143***
	(0.049)

Notes: The local linear regression is estimated with a rectangular kernel. The table presents estimates for the jump at the discontinuity for various bandwidths. Bootstrapped standard errors in parentheses (200 replications).

9. Appendix: Calculating the cost of a CS

To calculate the costs by mode of delivery, we use the 2012 Danish national prices for medical procedures. Counties are the local administrators of hospitals and use these prices, e.g., to calculate the overall medical costs or to calculate between-county transfers for medical procedures performed (Danish Ministry of Health and Prevention, 2009). The Ministry of Health defines the price per procedure and uses actual expenditures from the previous three years to calculate current prices. Calculating prices started in 1996, and from 2005 these prices became public available. In 2012, the prices by mode of delivery became much more detailed and included codes for different types of vaginal births, parity, and types of CS.

To define the average price per GP visit, we use information on fees for services to GPs for a random sample of 0-2 year old children in the pre-TBT period. This sample of approximately 14.000 children contains information from the Health Insurance Register (HIR). However, given sampling scheme and sample size we cannot use it in the main analysis.

The data from the HIR contains information on GP reimbursement. In Denmark, GPs have contracts that define their reimbursement as one-third capitation and two-thirds fee-for-service. In our data we observe the fees reimbursed to the GPs. While each fee for each service is linked to the patient, the number of services that each patient receives from the same GP is reported only on a weekly basis. As we use fees per week per GP for each patient as an indicator for expenditure per GP visit, we potentially overestimate the cost per visit if some children visit their GP more than once in one week. Furthermore, we assume in our calculation that breech babies have similar visits (and as a consequence result in similar reimbursements) to GPs as non-breech babies.

Table 9.1 relates the number of performed births to the costs by mode of delivery for breech babies, hospitalization and GP visits.

Table 9.1: Expenditure to the procedure, maternal hospitalzation and child's GP visits (1000 USD)

	Average pre-TBT expenditures to breech deliveries									
	Procedure			Hospitalization			GP visits			Total
	# births	Cost	Total cost	# days	Cost	Total cost	# visits	Cost	Total Cost	expenditure
CS (average)	1607	4,7	7524,6	4,5	2,8	20.224,3	16,3	0,034	898,6	
Vaginal births	964	5,9	5688,8	2,0	2,8	5.392,0	16,3	0,034	539,1	
Total	2571		13213,3			25.616,4			1437,7	40267,4
	Post-TBT increase of costs for the marginal breech babies									
	CS procedure			Hospitalization			GP visits			
	# births	Cost	Total change in cost	# days	cost	Total change in cost	# visits	cost	Total change in cost	Total expenditure
Change in outcome	360	-1,2	-438,8	2,2	2,8	2167,2	-10,6	0,034	-131,5	
Total change in cost			-438,8			2167,2			-131,5	1597,0
% change when related to pre-TBT average expenditures			-1,1			5,4			-0,3	4,0

Notes: We use the official 2012 prices per mode of delivery and maternal post-birth hospitalization. For CS we average over the prices for all types of CS for mothers with higher parity than one. To calculate the cost of a GP visit, we use GP reimbursement information from the Danish Health Insurance Register on a random sample of all 0-2 year old children in the pre-TBT period. The upper panel presents calculations of the average cost in the pre-TBT period. The lower panel presents the changes in average costs for the group of marginal breech babies.

10. ICD codes (WHOs International Classification System for Diseases) used in the paper

- Indicator for breech position: DO321, DO641, and DO641A
- Mothers hospital for prenatal care: the earliest ICD10 codes DZ34 and DZ35 during pregnancy (earliest prenatal care visit).
- Mothers birth hospital: ICD 10 birth codes.
- Breech babies with successful external cephalic versions: KMAB10. (KMAB10 and KMAB20 mark all attempts.)
- Measure of serious neonatal morbidity: DP10-15, DP20-29, DP50-61, DP90-96, DO69, and APGAR<4 at five minutes (DVA00-DVA03).
- Measure of frequent maternal post-birth complications: DO85, DO860, DO861C, DO862A, DK556H, DO871, DO882D, DO702, DF53, DO990A, and operation codes KMWA, KMWB, KMWC, KKCH00, KJFA70, KJFA80, KLCD00, KMBA, KMBB, KMBC00, KTAB30(Danish National Board of Health, 2005*b*).