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Annalisa Scognamiglio

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University of Naples Federico II
University of Salerno
Bocconi University, Milan

CSEF - Centre for Studies in Economics and Finance
DEPARTMENT OF ECONOMICS – UNIVERSITY OF NAPLES
80126 NAPLES - ITALY
Tel. and fax +39 081 675372 – e-mail: csef@unina.it
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Abstract
The cesarean rate in Italy is about 34%, higher than in other European countries and in the United States. It has been rising dramatically over the past decades and it varies considerably across geographical areas. I show that such geographical variation is not driven by medical need and that higher cesarean rates are achieved by performing the procedure on less and less appropriate patients. I find no evidence that high-use areas develop higher ability in performing cesareans. Finally, by using both panel data analysis and instrumental variables, I show that there is no significant relation between risk-adjusted cesarean rates and maternal and neonatal mortality. The combined evidence in this paper suggests that lowering cesarean rates would likely affect less appropriate patients, would not have negative spillovers in terms of quality of the procedure and would not affect neonatal nor maternal mortality.

Keywords: Cesarean section, neonatal and maternal health.

JEL Classification: I1, H42.

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* CSEF, Università di Napoli Federico II, Italy. E-mail: annalisa.sco@gmail.it Address: Department of Economics and Statistics, Via Cinthia Monte Sant'Angelo, 80126, Napoli, Italy.

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1 Introduction

The cesarean section rate in Italy is much higher than in other European countries and in the United States, and it has been increasing dramatically over the past three decades. Furthermore, there is considerable geographical variation in the use of cesarean sections: the unadjusted cesarean section rate in Campania, a region in Southern Italy, is above 60% while the lowest rate is recorded in the Autonomous Province of Bolzano in the North where it is around 25%. Even within the South some areas use cesareans at higher rates than others.

The literature on geographical variation in the use of cesarean sections has mostly focused on the United States (Baicker et al. [2006], Chandra and Staiger [2014], Currie and MacLeod [2013]). However, Italy represents a very interesting case because of its extremely high rates: in 2011 the highest cesarean rate in the United States, reached in New Jersey, was 40%, way below the 60% reached in Campania in Italy.

Such geographical variation and the extremely high levels of cesarean rates reached in some areas have recently attracted the attention of policy makers. The Department of Health initiated an investigation in 2012 in order to evaluate and punish abusive adoption of this procedure. Performing unnecessary cesarean sections has potential negative consequences on maternal and neonatal health. Furthermore, cesarean sections are more costly than vaginal deliveries. Given that the Italian healthcare sector is characterized by universal public insurance, and it is mostly funded through taxation, cutting unnecessary costs can help to reduce distortionary taxation and to allocate tax revenues in more efficient ways. Reducing the use of cesareans is an explicit goal set by the government in the 2012 National Health Plan.

This paper aims to contribute to this debate by analyzing the relationship between variation in cesarean rates and patients' suitability, ability in performing the procedure and maternal and neonatal mortality. I show that cesareans are performed on less and less appropriate patients and I test whether increases in cesarean rates have positive effects on ability in performing cesareans. Even though the marginal patients are not appropriate for the procedure, lowering cesareans rates might have negative effects on the quality of cesareans for the inframarginal patients. I find that the quality of cesareans does not increase with cesarean rates. Finally, I assess the relation between risk-adjusted cesarean rates and maternal and neonatal mortality using both panel data analysis and instrumental variables and I find no evidence that cesarean rates affect these outcomes.

In particular, following a standard empirical approach in this literature (e.g. Baicker et al. [2006]), I estimate a logistic model for the probability of delivery via cesarean section that includes a rich set of patient-level controls for risk-factors and area fixed effects and then build a measure of patients' suitability to the cesarean section as the estimated predicted probability of cesarean excluding the area fixed effects. The area-specific risk-adjusted cesarean rates are obtained by retrieving the estimated area fixed effects and computing the predicted probability of a cesarean at the average level of risk. A regression of the appropriateness measure on the logarithm of the area risk-adjusted cesarean rate shows that a 1% increase in the risk-adjusted cesarean rate corresponds to a 6.7 percentage points decrease in the appropriateness measure. By using time-varying measures of appropriateness and risk-adjusted cesarean rates, I show that a within-area increase in cesarean rates is associated with a decrease in appropriateness. These results suggest that high cesarean rates do not emerge from an increase in the use of cesarean sections all across the board but rather that the marginal patients become less appropriate as the risk-adjusted cesarean rate increases.

Even though cesareans are performed on less and less appropriate patients, areas characterized by higher risk-adjusted cesarean section rates might develop higher productivity in performing cesarean sections. I test this hypothesis by relating the probability of having complications following a cesarean section with the area risk-adjusted cesarean rate for the sub-sample of women that received a previous cesarean section. The probability of a repeat cesarean is about 94%. This fact helps to isolate the effect of ability in performing a cesarean section from compositional effects. I find that a 10 percentage points increase in risk-adjusted cesarean section rates corresponds to an about 3 percentage points increase in the probability of complications for repeat cesareans. This result is confirmed when I use an alternative strategy that relies only on within-region variation.

The last step in the analysis is to examine the relationship between maternal and neonatal mortality and area risk-adjusted cesarean rates. A simple OLS regression shows a large negative relation between cesarean rates and neonatal mortality while no relation is found for maternal mortality. With the inclusion of area fixed effects, however, the coefficient drops by more than half and becomes insignificant. No significant relation is found in a cross-sectional regression where the areas' risk-adjusted cesarean rates are instrumented with the fraction of female gynecologists.

The fact that physicians work down the patients' suitability curve is consistent with the view that the rise in cesarean rates is not driven by changes in patients' risk-factors but rather by financial incentives for doctors and hospitals (Gruber and Owings [1996], Gruber et al. [1999]), changes in patients' preferences and fear of malpractice lawsuits (Dubay et al. [1999]), but not implied by it. For instance, physicians driven by financial incentives might be uniformly more aggressive. The results in this paper suggest instead that non-medical motives change physicians' behavior at the margin, i.e. the threshold level of risk after which a cesarean is performed decreases as the cesarean rate increases.

Baicker et al. [2006] study the variation in the use of cesarean section across counties in the United States and find a negative relationship between average appropriateness and risk-adjusted cesarean rates and no significant correlation between mortality and cesarean rates. My contribution relative to Baicker et al. [2006] is two-fold: I propose a strategy to test whether ability in performing cesareans increases with cesarean rates and an instrumental variable strategy for the identification of the causal effect of cesarean rates on mortality outcomes. Furthermore, I focus on Italy where, as discussed above, cesarean rates reach much higher levels.

This is not the first paper to highlight the high levels of cesareans and the geographical variation in the use of cesareans in Italy. For instance, Francese et al. [2012] explore the impact of supply factors, pricing policies and political economy factors on regional variation in the use of cesarean sections, and Cavalieri et al. [2013] analyze the impact of DRG tariff differentials on the risk-adjusted cesarean section rates for first-time mothers during the period 2009-2011and find that hospitals respond to financial incentives. To the best of my knowledge, however, this is the first study that highlights the negative relation between area use rates and patients' suitability in Italy, and that proposes a way to assess the effects on both quality of the procedure and mortality outcomes.

The rest of the paper proceeds as follows: section 2 documents the geographical variation and the upward trends in cesarean rates. Section 3 discusses potential explanations for the rise in cesarean sections. Section 4 analyzes the relation between patients' suitability and regional variation in risk-adjusted cesarean rates. Section 5 shows the relation between cesarean rates and ability in performing c-sections. Section 6 relates risk-adjusted cesarean rates to maternal and neonatal mortality, and section 7 concludes.

2 Geographical Variation and Trends in Cesarean Section Rates

The rate of cesarean section in Italy has been increasing substantially over time. Figure 1 shows the time series of cesarean section rates from 1980 to 2012. In 1980 there were about 11 cesarean sections per 100 live births, but such number doubles by 1990 and keeps increasing over time, reaching a peak of about 40 cesarean sections per 100 live births in 2007. An upward trend in the use of cesarean sections has been recorded in several countries. However, as shown in figure 2, the rate of cesarean sections is higher in Italy than in other OECD countries. For instance, the cesarean rate in Italy is 15 percentage points higher than in Spain, and about 7 percentage points higher than in the United States.

The increase in the use of cesarean sections, however, was not homogeneous across geographical areas. The evolution of unadjusted cesarean rates over time across Italian regions highlights substantial variation across geographical areas in both the levels and the trends. In the early 1980s cesarean rates in the Southern regions are comparable to those in the Northern and Central regions, but they evolve on steeper trends. By 1996 the lowest cesarean rate among the Southern regions, i.e. 28.2 in Calabria, is about 3 percentage points higher than the highest rate among the Northern regions. Campania shows the most impressive rise in cesarean rates: from 8.5% in 1980 to about 62% in 2011. Just in the decade between 1990 and 2000 the cesarean rate increases in Campania from 20% to more than 50%. Figure 3 shows that, even though cesarean rates are very high in all Southern regions, there is sizable variation with a 20 percentage points difference between the highest (Campania) and the lowest (Calabria) in 2010. Furthermore, as figure **??** in the appendix shows, there is considerable variation also across provinces within the same region, both in levels (left panel) and trends (right panel).

3 Potential Explanations for the Trends in Cesarean Rates

Upward trends in cesarean section rates have been observed in several countries. For instance, in the United States the cesarean section rate has increased from about 22% in 1990 to 30% in 2005. The medical literature (e.g. Ecker and Frigoletto [2007]) has suggested several factors that can explain the observed rise in cesarean section rates: technological changes that make cesarean deliveries less risky, e.g. the development of new anesthetic techniques, the introduction of modern antibiotics and the creation of neonatal intensive care units, and the diffusion of diagnostic techniques that increase the likelihood of a pregnancy being identified as benefiting from a cesarean delivery, e.g. the development of pre-delivery diagnostic techniques for the fetus. The reduction in the use of forceps, following studies that highlighted the risks for the fetuses, also contributes to the rise in cesarean sections. Compositional changes of the mothers, e.g. the increase in mothers' age and obesity, and changes in preferences, e.g. the change in the risk threshold that are considered acceptable, also play a role in the rise of cesarean sections.

The factors highlighted above can help explain the upward trend in Italy as well. Figure 4 shows that average mothers' age at delivery has increased over time. However, the increase in the South and the Islands, where cesarean rates increased the most, is smaller than in other areas. Furthermore, there have been dramatic social and economic changes over the past decades in Italy that might have determined changes in preferences toward type of delivery. For instance, the share of women with college degree has increased from 4.9% in 1993 to 12.3% in 2012, and female labor force participation has increased from about 42% in 1993 to 53.5% in 2012. As shown in figure 5, the fertility rate has also been changing dramatically over the past decades, and its evolution followed different patterns across areas. The fertility rate has been decreasing over time in Southern Italy whereas it exhibits a U-shaped evolution in Northern and Central Italy. This fact might contribute to the differences in the evolution of cesarean rates across these broad areas. Indeed, there is a negative correlation between cesarean rates and fertility rates within provinces, robust to the inclusion of region by year fixed effects. It is hard, however, to argue for a causal interpretation, as omitted variable bias is likely to be present in this context. Other potential factors explaining the fast rise in cesarean rates are the use of repeat cesarean and the existence of spillovers effects, for which an increase in cesarean rates is self-reenforcing over time - e.g. as cesarean rates increase, the option for a cesarean section is perceived as more and more "natural" by both mothers and physicians.

The economic literature has focused on changes in physicians' behavior as a potential explanation for the rise in cesarean section rates. In particular, the literature has mostly looked at two potential factors influencing physician practice:

1. Malpractice lawsuits: the increased fear of malpractice lawsuits, often alleging a failure to perform timely cesarean delivery, might induce physicians to opt for cesarean sections. There is, however, conflicting evidence on this matter. For instance, Dubay et al. [1999] find a positive relation between malpractice premiums and the use of cesarean sections whereas Baicker and Chandra [2005] and Kim [2007] find no evidence of an impact of malpractice fear on the use of cesarean sections. Malpractice lawsuits are on the rise in Italy as well. DiMarzo [2012] reports that between 1994 and 2008 the number of claims filed annually against hospitals and medical practitioners increased from 3,150 to almost 30,000.

2. Incentive effects of the payment system: if the net financial benefit of performing a cesarean section is higher than for a vaginal delivery, providers have incentives to induce demand for the former rather than the latter. Gruber and Owings [1996] hypothesize that the fall in fertility rates represents a negative income shock for physicians and find that providers substitute from vaginal deliveries to cesarean sections, characterized by a higher reimbursement, to compensate for the decrease in volumes. Gruber et al. [1999] compare privately insured patients with Medicaid patients and find a positive impact of tariff differentials on the probability of cesarean delivery.

In line with this literature, an additional factor that can help explain the rise in cesarean rates in Italy is the introduction in 1992-1993 of dramatic changes to both the organizational structure and the reimbursement system of the National Health System. With the laws 502/1992 and 517/1993, the Italian National Health System goes from being a highly centralized system to a decentralized system, both in terms of organization and of funding for the provision of healthcare services. More powers are given to the Regions, together with the responsibility for balancing the budgets. The Local Health Authorities go from being operational units subject to the control of the municipalities to corporations. The relationship between public insurance and private providers, previously based mostly on bilateral agreements for the provision of healthcare services, is fully reorganized. Finally, the funding system changes toward increasing competition among hospitals, by introducing the reimbursement system based on the DRGs and allowing public for fee services - i.e. public providers can practice as private professionals using the facilities of the public hospitals. The introduction of several fundamental changes at once and the potential for complementarities in these changes makes it difficult to identify the causal impact of each of them. Furthermore, the trends in the use of cesarean sections across provinces start diverging already before the introduction of the reform. So, even though the reform had an impact on the use of cesarean sections, it is difficult to capture.

The discussion above suggests that the increase in cesarean sections experienced in Italy and especially in some areas might be driven by reasons other than growing medical need. Geographical variation in the use of cesarean section is thus likely the result of such non-medical factors affecting different areas in different ways. The analysis that follows focuses on understanding the implications of the importance of non-medical factors in terms of physician behavior and patients' outcomes.

4 Geographical Variation in the Use of Cesarean Section and Patients' Appropriateness

Section 2 documents substantial variation in the use of cesarean sections across geographical areas in Italy. A large literature in medicine documents the existence of geographical variation in the use of intensive health treatments, unrelated to outcomes, and has often explained it with a "flat of the curve medicine" argument - i.e. physicians use high-intensity procedures up to to the point in which the marginal product is zero. The economics literature has offered alternative explanations for the observed facts. For instance, Chandra and Staiger [2007] test a Roy model with productivity spillovers for the use of surgical procedures for the treatment of heart attacks and find higher returns from surgery for most appropriate patients in high-intensity areas, while there is no relationship between overall outcomes and area intensity. Several papers focus specifically on geographical variation in the use of cesarean section. Baicker et al. [2006] show that there is sizable variation in the use of cesarean sections across counties in the US. They further show that the average appropriateness of patients decreases with the area's risk-adjusted cesarean rate while there is no significant relation with maternal and neonatal mortality.

This section analyzes the relation between patients' suitability and geographical variation in the use of cesarean sections in Italy. In particular, I test whether there is a negative relation between appropriateness and risk-adjusted regional cesarean section rates among the women that received a cesarean section. This allows one to identify whether physicians in high-use areas perform cesarean sections on increasingly less suitable patients.

4.1 Microdata - Survey on Health Condition and Healthcare Utilization

The patient level data is obtained from the 2004/2005 Survey on Health Conditions and Healthcare Utilization. The survey provides a full account of individual health, healthcare use, demographics and socio-economic status and has an additional section about pregnancy, childbirth delivery and breast-feeding which is filled in by all women in the sample that had a baby in the previous five years. The 2004-2005 survey includes 50,474 households for a total of 128,040 individuals. The pregnancy/childbirth delivery section is filled in by 5,812 women. Table 1 reports the fraction of births via cesarean. Among all births 35% happen via cesarean section, 63% of which are scheduled cesarean sections (column (1), table 1). Column (2) restricts the sample to women with no previous cesarean section. Among them the fraction of women receiving a cesarean section is substantially lower and equal to 26%, and only 13% of mothers with no previous cesarean section have a scheduled cesarean. Table 2 shows that there is substantial variation across geographical areas in the use of cesarean sections, both in the full sample of births and in the sub-sample of mothers that did not have previous cesarean sections. The fraction of cesarean births is 15 percentage points higher in the South and the Islands than in the North. The gap is smaller in the sub-sample of mothers that did not have previous cesarean births, but it is still sizable - i.e. the fraction of cesarean births in the South and the Islands is 11 percentage points higher than that in the North.

4.2 Empirical Strategy and Results

Following the literature (Baicker et al. [2006], Chandra and Staiger [2007]), I estimate a logistic model for the probability of receiving a cesarean section that includes a rich set of patient-level controls and region fixed effects:

$$\Pr\left(\mathrm{CS}_{ij} = 1 \middle| X_{ij}, \theta_j\right) = \mathrm{F}\left(\theta_0 + \theta_j + \beta X_{ij}\right) \tag{1}$$

where i indexes a patient, θ_j are region fixed effects and F (.) is the logistic distribution. Table 3 gives summary statistics and a description of all the variables included as controls. The measure of appropriateness used in the analysis below is built as the predicted probability of receiving a cesarean section net the region fixed effects, $Appropriateness_{ij} = \mathrm{F}\left(\hat{\theta}_0 + \hat{\beta}X_{ij}\right)$. The estimated region fixed effects are used to build regional risk-adjusted cesarean section rates, $RACR_j = \mathrm{F}\left(\hat{\theta}_0 + \hat{\theta}_j + \hat{\beta}\overline{X}\right)$, where $\overline{X}$ is the vector of the controls' means. The variation in the cesarean rates across regions is not explained by differences in the distribution of risk-factors but rather the risk-adjusted rates for some regions are higher than the corresponding unadjusted rates, i.e. cesarean rates in some areas are higher than what the model would predict given the distribution of patients' characteristics. This means that the regional variation in cesarean rates is driven by factors others than patients' characteristics, e.g. supply factors, physician practice style etc, but it does not tell us much about the model that drives the increases in cesarean rates.

In order to test whether doctors walk down the distribution of patients' observable appropriateness, I correlate the area risk-adjusted cesarean rates with average appropriateness of patients that receive a cesarean section. If doctors in high-use areas perform cesarean sections on less appropriate patients we should observe a negative relationship between average appropriateness and risk-adjusted cesarean rates. Figure 6 shows that average appropriateness for cesarean births is lower in regions with higher risk-adjusted cesarean rates. Notice that this is not a mechanical relationship. As discussed in Baicker et al. [2006], both a positive relationship and a zero relationship can arise. For instance, if doctors in high-use areas are uniformly more aggressive and perform more cesarean sections for all appropriateness levels we would find no correlation. A simple example can help to understand the logic. Suppose that there are only two observable types of patients, A and B, and two regions, 1 and 2. For simplicity assume that in both regions patients are evenly distributed across the two types. Type-A patients are more likely to need a cesarean section than type-B patients. In particular, 20% of type-A patients and 10% of type-B patients need a cesarean. Region 1 has exactly these proportions, while region 2 performs cesareans on 40% of type-A patients and 20% of type-B patients. The average predicted probability of a cesarean delivery among cesarean births is the same in the two regions, but the risk-adjusted cesarean rate in region 2 is higher.

In the same spirit I test whether the marginal cesarean birth has lower appropriateness than the average cesarean birth. The estimating equation is

$$Appropriateness_{ij} = \alpha + \beta \cdot \log(RACR_j) + \epsilon_{ij} \tag{2}$$

and the sample is restricted to cesarean births only. The coefficient β in equation 2 measures the difference between the predicted probability of a cesarean section for the marginal cesarean birth and the average cesarean birth. A negative β means that doctors perform cesareans on less and less appropriate patients as the cesarean rate increases.

Table 4 reports the coefficient estimates for model 2. The appropriateness measure and the regional risk-adjusted cesarean section rates in column (1) in table 4 are obtained as described above, while column (2) refers to births via scheduled cesarean. This means that the appropriateness measure and the risk-adjusted cesarean rates are obtained from model 1 using a dummy variable that equals one for scheduled cesarean and zero for vaginal births as well as unscheduled cesarean births. Panel A, B and C in table 4 respectively use the samples of all birth-weights, low birth-weights - i.e. birth-weight at or below 2.5kg, and normal birth-weights - i.e. birth-weight above 2.5kg. The relationship between appropriateness and regional risk-adjusted cesarean rates is negative in all sub-samples. A 1% increase in the regional risk-adjusted cesarean section rate corresponds to a 6.7 percentage points decrease in appropriateness for normal birth-weights, and to a 20 percentage points decrease in appropriateness for the sub-sample of low birth-weights. The point estimates are smaller and less precise when considering scheduled cesarean sections (column (2) in table 4) but there is still a sizable negative relationship between appropriateness and scheduled cesarean rates, suggesting that, as the rate of scheduled cesarean sections increases, doctors schedule cesareans for less appropriate women.

As documented above, cesarean section rates were on the rise everywhere in Italy. However the growth rates exhibit cross-sectional variation. This allows me to construct a strategy that uses within-region variation to test whether an increase in the regional risk-adjusted cesarean rate corresponds to a decrease in appropriateness. I build time-varying measures of appropriateness and risk-adjusted cesarean section rates by following the procedure described above. In order to allow for changes in the responsiveness to risk factors over time, I estimate model 1 in section 4 separately for the different time periods. For instance, this allows for technological changes to affect the way different risk factors influence the probability of cesarean birth.

The estimating equation to test this hypothesis is

$$Appropriateness_{ijt} = \alpha_j + \lambda_t + \beta \cdot \log(RACR_{jt}) + \epsilon_{ijt} \quad (3)$$

where y_{ijt} is the outcome for mother i in region j in time period t, α_j are region fixed effects and λ_t are time-period fixed effects. The areas' time-varying risk-adjusted cesarean rates are obtained by following the procedure in the previous section where model 1 is estimated separately on the two time periods, 1998-2002 and 2003-2005. Table 5 reports the estimates for equation 3: a 1% increase in within-region risk-adjusted cesarean rates is associated with a 20 percentage points decrease in the appropriateness measure. I interpret this finding as evidence of a decrease in the threshold level of patients' appropriateness after which cesarean sections are performed.

5 Regional Risk-Adjusted Cesarean Rates and Ability in Performing Cesarean Sections

Areas characterized by higher risk-adjusted cesarean section rates might develop higher productivity in performing cesarean sections. I test this hypothesis by relating the probability of having complications following a cesarean section with the areas risk-adjusted cesarean rates for the sub-sample of women that received a previous cesarean section. About 94% of the births following a cesarean birth happen via cesarean section. This fact helps isolating the effect of the ability in performing a cesarean section from compositional effects. Using the full sample of mothers would lead to a mechanical relation between the incidence of problems related to childbirth delivery, due to the fact that some problems are more likely to appear following a cesarean section. Restricting the attention to cesarean birth also presents some problems. Table 6 shows that, for the sub-sample of cesarean births, a 10 percentage points increase in the area's risk-adjusted cesarean rate corresponds to a 3 percentage points decrease in the probability of any problem occurring following childbirth delivery and to a 1.2 percentage points increase in the probability of healing problems. However, the compositional differences across areas in the group of cesarean births do not allow to isolate the effect of ability. As shown in the previous sections, patients' suitability decreases with the cesarean rate. The estimates in table 6 are thus the joint effect of decreased appropriateness and changes in ability. I restrict the sample to women with previous cesarean sections in order to reduce concerns related to mechanical effects and compositional differences across areas. Table 7 shows the relation between the probability of complications and the area's risk-adjusted cesarean rate, obtained by estimating linear probability models of outcomes on regional risk-adjusted cesarean rates and patient level controls. The outcome in column (1) in table 7 is a dummy variable that equals one if a mother experiences any complication following childbirth delivery. A 10 percentage points increase in the risk-adjusted cesarean rate corresponds to a 1.53 percentage points decrease in the probability of having any problem, but the estimate is very imprecise. The outcomes in columns (2) and (3) are dummy variables that equal one if a mother experiences respectively healing complications and gynecological problems following childbirth delivery. A 10 percentage points increase in risk-adjusted cesarean section rates corresponds to an about 3 percentage points increase in the probability of healing problems, while the relation between the incidence of gynecological problems and areas' risk-adjusted cesarean rates is small and insignificant. While the probability of receiving a cesarean section conditional on having received one before is very high everywhere, there is sizable geographical variation. Higher incidence of healing problems might thus be partly explained by the increase in the fraction of cesarean births. Controlling for the fraction of women receiving a cesarean section (not reported) changes the coefficients only marginally. These findings go against the hypothesis that areas that perform more cesarean sections have higher ability than low-cesarean rates areas. Table 8 shows the relation between bad outcomes and cesarean rates using only within region variation. The coefficients in table 8 are obtained by splitting the dataset in two time periods, 1998-2002 and 2003-2005, and estimating the following model

$$y_{ijt} = \alpha_j + \lambda_t + \beta RACR_{jt} + \epsilon_{ijt} \tag{4}$$

where y_{ijt} is the outcome for mother i, in region j, in time period t, α_j are region fixed effects and λ_t are time-period fixed effects. The areas' time-varying risk-adjusted cesarean rates are obtained by following the procedure in the previous section where model 1 is estimated separately on the two time periods, 1998-2002 and 2003-2005. Table 8 shows that increases in areas' risk-adjusted cesarean rates correspond to increases in the probability of complications following childbirth delivery for mothers with previous cesarean sections.

A 10 percentage points increase in areas' risk-adjusted cesarean rate is associated to a 4.4 percentage points increase in the probability of healing problems, but the estimate is imprecise. One caveat to the analysis described in this section is that, although the probability of a second cesarean is very high, unobservable compositional differences across areas can derive from selection into the first cesarean. However, the analysis including fixed effects helps overcoming this caveat and confirms the result that higher cesareans rates are not related to higher ability in performing cesarean sections.

6 Maternal and Neonatal Mortality and Cesarean Rates

The results in the previous sections show that, as cesarean rates increase, physicians perform cesarean sections on less and less appropriate patients. Furthermore, I do not find evidence that an increase in cesarean rates is associated with improved quality of cesarean sections. This section studies the relationship between maternal and neonatal mortality and areas' risk-adjusted cesarean rates.

6.1 The Data

The data on neonatal and maternal mortality is part of the Health for All - Italy database, an information system that collects health data from several sources in order to provide an overview about health conditions and supply and demand of health care services. It contains about 4000 indicators of demographics, causes of deaths, hospital discharges by diagnosis, life styles, health care resources and life expectancy. Neonatal mortality is defined as the number of deaths within the first 29 days of life per 10,000 live births. Maternal mortality is defined as the number of deaths for which "complications of pregnancy, childbirth, and the puerperium" is listed as the primary cause of death per 10,000 births. Both variables are available at the province level ($N = 109$) from 2007 to 2011.

The National Program for the Evaluation of Healthcare Services provides data on unadjusted cesarean rates and risk-adjusted cesarean rates at hospital level from 2007 to 2012[1]. I compute the average cesarean rates by province and merge this data with the mortality data. The mean and standard deviations of maternal

[1]The risk-adjustment procedure used by the National Program for the Evaluation of Healthcare Services for cesarean rates is based on logistic regressions including a variety of patient-level risk-factors. Detailed information about the methods are available online at http://95.110.213.190/PNEed13/.

mortality are, respectively, 0.29 and 1.25. Neonatal mortality has mean 15.24 and standard deviation 9.54.

6.2 Empirical Strategies and Results

In order to study the relationship between maternal and neonatal mortality and areas' cesarean rates I use two different empirical strategies. First, I estimate the following model using OLS:

$$y_{pgt} = \alpha_p + \lambda_{gt} + \beta \cdot RACR_{pt} + \epsilon_{pgt} \tag{5}$$

where y_{pgt} is either maternal or neonatal mortality in province p in area $g \in \{North, Center, South\}$ and year t, $RACR_{pgt}$ is the risk-adjusted cesarean rate, α_p are province fixed effects and λ_{gt} are area-specific year fixed effects. Table 9 reports the estimate for β in equation 5. The specifications in column (1) and (2) do not include province fixed effects. Maternal mortality is not associated with risk-adjusted cesarean rates whereas neonatal mortality appears to be correlated with cesarean rates: a 10 percentage points increase in the risk-adjusted cesarean rate is associated with about 1 less death per 10,000 live births. With the inclusion of province fixed effects and area-specific year effects in column (4), however, the point estimate drops by half and becomes insignificant.

If changes in the risk-adjusted cesarean rates are correlated to shocks to neonatal and maternal mortality, the coefficients in table 9 do not have a causal interpretation. In order to use the cross-sectional variation, without relying on the assumption that differences in cesarean rates are uncorrelated with other characteristics that also affect mortality, I use the fraction of female gynecologists in province p to instrument for the average risk-adjusted cesarean rate in province p over the sample period 2007-2011. The structural equation of interest is

$$\bar{y}_p = \alpha + \beta \cdot \overline{RACR_p} + \epsilon_p \tag{6}$$

where $\bar{y}_p$ and $\overline{RACR_p}$ are, respectively, the mortality outcomes and the risk-adjusted cesarean rate averaged across the sample period 2007-2011. I instrument $\overline{RACR_p}$ using the fraction of female gynecologists in province p in the year 2011. If female gynecologists attribute more importance to the choice of the delivery type, they might also be less incline to perform cesarean sections on less suitable patients. I assume that the probability of being followed during pregnancy by a female gynecologist is exogenously higher in areas with a higher fraction of female gynecologists. If female doctors are more involved at an emotional level in the choice of the delivery type we would expect the cesarean rate to decrease with the fraction of female gynecologists. Panel C in table 10 shows the first stage coefficient: a 10 percentage points increase in the fraction of women reduces the risk-adjusted cesarean rate by 1.9 percentage points. Column (1) in table 10 shows that there is no significant relationship between maternal mortality and risk-adjusted cesarean rates within area (panel A) whereas a 10 percentage points increase in the risk-adjusted cesarean rate corresponds to about 0.9 more neonatal deaths per 10,000 births (panel B), although such relationship is imprecisely estimated. The OLS relationship between mortality and risk-adjusted cesarean rates are likely to suffer from omitted variable bias due to unobservable patients' or provinces' characteristics. Indeed, column (3) in panel B in table 10 shows that the 2SLS coefficient for neonatal mortality is about zero, thus suggesting that a decrease in cesarean rates would not affect neonatal mortality. Notice, however, that the 2SLS estimates are imprecise, so some caution is needed in drawing conclusions. Column (3) in panel A shows that there is no significant effect of cesarean rates on maternal mortality. However, the point estimate is larger than the OLS estimate, but imprecisely estimated. It is not possible to conclude with certainty that maternal mortality is not benefited by higher cesarean rates.

One concern with the IV strategy described above is that the fraction of female gynecologists might affect neonatal and maternal health via channels other than the choice of whether to perform a cesarean section or not, thus violating the exclusion restriction. For instance, a higher fraction of female gynecologists might improve overall gynecological health thus biasing the effect on mortality toward zero. As a check for the presence of this channel I look at the relation between mortality rates due to breast cancer and the fraction of female gynecologists. Table 11 shows that there is no significant relationship between mortality for breast cancer and the fraction of female gynecologists. Although there can still be concerns about the exclusion restriction, this result is reassuring.

7 Conclusions

This paper documents the existence of sizable variation in the use of cesarean sections in Italy across geographical areas and over time. It then shows that patients' suitability to cesarean sections decreases as risk-adjusted cesarean rates increase. High-use areas do not seem to have higher ability in performing cesarean sections relative to other areas, nor do they seem to develop higher ability in performing cesareans with the increase in the use of this procedure over time. Finally, it assesses the relation between risk-adjusted cesarean rates and maternal and neonatal mortality using both panel data analysis and instrumental variables and finds no evidence that cesarean rates affect these outcomes.

These results suggest that high cesarean rates do not emerge from an increase in the use of cesarean sections all across the board but rather doctors target cesarean sections towards more appropriate patients in general, so as the cesarean rates rise for non-medical reasons, the suitability of patients for cesareans at the margin declines.

Even though cesareans are performed on less and less appropriate patients, areas characterized by higher risk-adjusted cesarean section rates might develop higher productivity in performing cesarean sections. I test this hypothesis by relating the probability of having complications following a cesarean section with the area's risk-adjusted cesarean rate for the sub-sample of women that received a previous cesarean section. I find that a 10 percentage points increase in the risk-adjusted cesarean section rate corresponds to an about 3 percentage points increase in the probability of complications. Using a fixed effects panel data regression I further show that the risk-adjusted cesarean rate is also positively related to the probability of complications following a cesarean section for women that had a previous c-section.

The last step in the analysis is to examine the relation between maternal and neonatal mortality and the area's risk-adjusted cesarean rate. No significant relation is found using within-province variation nor in a cross-sectional regression where the risk-adjusted cesarean rate is instrumented with the fraction of female gynecologists.

The combined evidence presented in this paper supports the view that lowering cesarean sections would not have negative consequences on patients' outcomes, but rather could benefit patients and surely reduce the costs for healthcare provision.

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Table 1

FRACTION OF CESAREAN BIRTHS

	All births	No previous cesarean
Any Cesarean	0.35	0.26
Scheduled Cesarean	0.22	0.13
N	5812	5000

Column (1) reports the fraction of cesarean births among all births. Column (2) reports the fraction of cesarean births among mothers that did not have a previous cesarean section. Any Cesarean is a dummy that equals 1 for any cesarean birth. Scheduled Cesarean is an indicator variable that equals 1 for births via scheduled cesarean and 0 else.

Table 2

FRACTION OF CESAREAN BIRTHS BY GEOGRAPHICAL AREA

Area	North-East	North-West	Center	South and Islands
Panel A: All births				
Any Cesarean	0.28	0.27	0.34	0.43
Scheduled Cesarean	0.14	0.14	0.20	0.29
N	1136	1228	990	2026
Panel B: No previous cesarean section				
Any Cesarean	0.21	0.19	0.24	0.32
Scheduled Cesarean	0.09	0.08	0.10	0.19
N	1017	1075	844	2458

Panel A reports the fraction of cesarean births and scheduled cesarean births among all births by geographical area. Panel B reports the fraction of cesarean births and scheduled cesarean births among mothers that do not have previous cesarean sections.

Table 3

Summary Statistics for the Control Variables

	mean	sd
Amniocen=1 if the woman underwent prenatal diagnostic checks	0.30	0.46
Diabetes=1 if the woman reports having suffered from diabetes during pregnancy	0.02	0.15
Gestosis=1 if the woman reports having suffered from gestosis	0.03	0.18
Hypertension=1 if the woman reports having suffered from hypertension during pregnancy	0.04	0.20
Body Mass Index	229.67	36.11
Birthweight in kg	3.25	0.51
Hospitalization=1 if the woman was hospitalized during pregnancy	0.66	0.47
Smoking=1 if the woman was an abitual smoker	0.22	0.42
Age below 24	0.05	0.22
Age above 35	0.25	0.43
Primipar	0.43	0.49
Previous Cesarean	0.14	0.35
Gestation month at delivery:		
6th month=1 if delivery happens at 6th month of pregnancy	0.00	0.04
7th month=1 if delivery happens at 7th month of pregnancy	0.02	0.12
8th month=1 if delivery happens at 8th month of pregnancy	0.07	0.25
Low Education=1 if the woman holds a low-education degree	0.45	0.50
High Education=1 if the woman holds a high-education degree	0.12	0.33
Employed=1 if the woman is employed	0.54	0.50
Never Married=1 if the woman was never married	0.07	0.26
Divorced=1 if the woman is divorced	0.02	0.13
Widowed=1 if the woman is widowed	0.01	0.07
Separated=1 if the woman is separated	0.02	0.15
Dummy for Quarter of Birth 1	0.24	0.43
Dummy for Quarter of Birth 3	0.26	0.44
Dummy for Quarter of Birth 4	0.26	0.44
Dummy for Year of Birth 98-99	0.10	0.30
Dummy for Year of Birth 2000	0.15	0.36
Dummy for Year of Birth 2001	0.15	0.35
Dummy for Year of Birth 2003	0.18	0.39
Dummy for Year of Birth 2004	0.19	0.39
Dummy for Year of Birth 2005	0.06	0.23
N	5790	

The table reports the definition and mean and standard deviation for all the variables used in the logistic model to build the appropriateness measure and the risk-adjusted cesarean rates.

Table 4

Appropriateness and Risk-Adjusted Cesarean Rates

	Predicted Probability of:	
	Any Cesarean	Scheduled Cesarean
	(1)	(2)
	Panel A: All birthweights	
log(RACR)	-0.067**	-0.052*
	(0.021)	(0.020)
cons	0.474***	0.316***
	(0.026)	(0.030)
N	2027	1270
	Panel B: Low birthweights	
log(RACR)	-0.196***	-0.143**
	(0.045)	(0.036)
cons	0.330***	0.142**
	(0.024)	(0.038)
N	231	124
	Panel C: Normal birthweights	
log(RACR)	-0.062**	-0.057*
	(0.019)	(0.021)
cons	0.475***	0.315***
	(0.025)	(0.032)
N	1796	1146
N clusters	21	21

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

The dependent variable in column (1) is the predicted probability of any cesarean section. The dependent variable in column (2) is the predicted probability of a scheduled cesarean section. Panel A reports the estimates for all birthweights, panel B reports the estimated coefficients for the sub-sample of low-birthweight births (at or below 2.5kg) and panel C reports the estimates for the sub-sample of normal-birthweight births (above 2.5kg). RACR is the risk-adjusted cesarean rate for column (1) and the risk-adjusted rate of scheduled cesareans in column (2).

Table 5

Appropriateness and Risk-Adjusted Cesarean Rates Within Region

	Appropriateness
log(RACR)	-0.194**
	(0.056)
I(2003-2005)	0.077***
	(0.014)
cons	0.312***
	(0.059)
Region Fixed Effects	Yes
N	2027
N clusters	21

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

The data is divided in two time periods: 1998-2002 and 2003-2005. Each time period is used to get separate estimates for both appropriateness and areas' risk-adjusted cesarean rates. Standard errors clustered at region level in parentheses. The omitted time period is 1998-2002. RACR is the risk-adjusted cesarean rate.

Table 6

Complications and Risk-Adjusted Cesarean Rates
Sub-sample of Cesarean Births

	Any Problem	Healing Problems	Gynecological Problems
	(1)	(2)	(3)
RACR	-0.235*	0.115	0.065
	(0.109)	(0.076)	(0.062)
N	2038	2038	2038
N clusters	21	21	21

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

All regressions include the full set of patients' controls described in the previous section. The outcomes in columns (1) to (3) are dummy variables that equal one if a woman experienced any complication, healing problems or gynecological problems following childbirth delivery. RACR is the risk-adjusted cesarean rate. Standard errors (in parentheses) are clustered at the region level.

Table 7

Complications and Risk-Adjusted Cesarean Rates
Sub-sample of Women with previous Cesarean Sections

	Any Problem	Healing Problems	Gynecological Problems
	(1)	(2)	(3)
RACR	-0.153	0.278**	-0.049
	(0.138)	(0.094)	(0.075)
N	753	753	753
N clusters	21	21	21

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

All regressions include the full set of patients' controls described in the previous section. The outcomes in columns (1) to (3) are dummy variables that equal one if a woman experienced any complication, healing problems or gynecological problems following childbirth delivery. RACR is the risk-adjusted cesarean rate. Standard errors (in parentheses) are clustered at the region level.

Table 8

Complications and Risk-Adjusted Cesarean Rates Within Region
Sub-sample of Women with previous Cesarean Sections

	Any Problem	Healing Problems	Gynecological Problems
	(1)	(2)	(3)
RACR	-0.100	0.437*	0.295
	(0.218)	(0.175)	(0.183)
I(2003-2005)	-0.018	-0.014	-0.003
	(0.049)	(0.032)	(0.016)
cons	0.523***	0.004	-0.023
	(0.071)	(0.062)	(0.065)
Region fixed effecs	Yes	Yes	Yes
N	812	812	812
N clusters	21	21	21

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

The outcomes in columns (1) to (3) are dummy variables that equal one if a woman experienced any problem, healing problems or gynecological problems following childbirth delivery. All models include region fixed effects. The data is divided in two time periods: 1998-2002 and 2003-2005. Each time period is used to get separate estimates for areas' risk-adjusted cesarean rates.

Table 9

Mortality and Cesarean Rates: Panel Data Analysis

	Maternal Mortality		Neonatal Mortality	
	(1)	(2)	(3)	(4)
RACR	-0.002	0.003	0.114***	0.016
	(0.002)	(0.004)	(0.032)	(0.013)
Province Fixed Effects	No	Yes	No	Yes
Area Fixed Effects	Yes	No	Yes	No
Year Fixed Effects	Yes	Yes	Yes	Yes
Area by Year Fixed Effects	No	Yes	No	Yes
N	523	523	523	523
Nclusters	108	108	108	108

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

RACR is the risk-adjusted cesarean rate (in percentage points) at province level as computed by the National Program for the Evaluation of Healthcare Services. The specifications in columns (1) and (3) include dummies for North, Center and South and years fixed effects. The specifications in columns (2) and (4) include province fixed effects and area-specific year effects. Maternal mortality is the number of deaths due to complications during pregnancy and childbirth delivery per 10,000 births. Neonatal mortality is the number of deaths within 29 days from birth per 10,000 live births. Standard errors are clustered at the province level.

Table 10

Mortality and Cesarean Rates: IV Estimates

	OLS (1)	Reduced Form (2)	2SLS (3)
Panel A: Maternal Mortality			
RACR	-0.004		-0.024
	(0.006)		(0.034)
Fraction of Female Gynecologists		0.474	
		(0.679)	
Panel B: Neonatal Mortality			
RACR	0.086		0.008
	(0.048)		(0.265)
Fraction of Female Gynecologists		-0.146	
		(5.266)	
Panel C: First Stage			
		RACR	
Fraction of Female Gynecologists		-19.394*	
		(9.546)	
Area Fixed Effects	Yes	Yes	Yes
N	109	109	109

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Column (1) reports OLS estimates of the relationship between mortality and risk-adjusted cesarean rates. Column (2) reports the estimated relationship between the outcomes and the fraction of female gynecologists. Column (3) reports the 2SLS estimates of the relationship between mortality and risk-adjusted cesarean rates. All specifications include dummies for the North and the South. The outcome in panel A is defined as the number of deaths due to complications during pregnancy and childbirth delivery per 10,000 births, whereas panel B reports the estimates for neonatal mortality and panel C reports the first stage coefficient from a regression of Risk-Adjusted Cesarean Rates on the fraction of female gynecologists and dummies for the North and the South. RACR is the risk-adjusted cesarean rate expressed in percentage points. Robust standard errors in parentheses.

Table 11

Supporting Evidence for the Exclusion Restriction: Mortality for Breast Cancer and Fraction of Female Gynecologists

	Breast Cancer Mortality Rate
	(1)
Fraction of Female Gynecologists	0.458
	(0.636)
SOUTH	-0.328*
	(0.157)
NORTH	0.865***
	(0.141)
_cons	3.466***
	(0.341)
N	109

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Mortality for breast cancer is the number of deaths due to breast cancer per 10,000 women. Robust standard errors in parentheses.

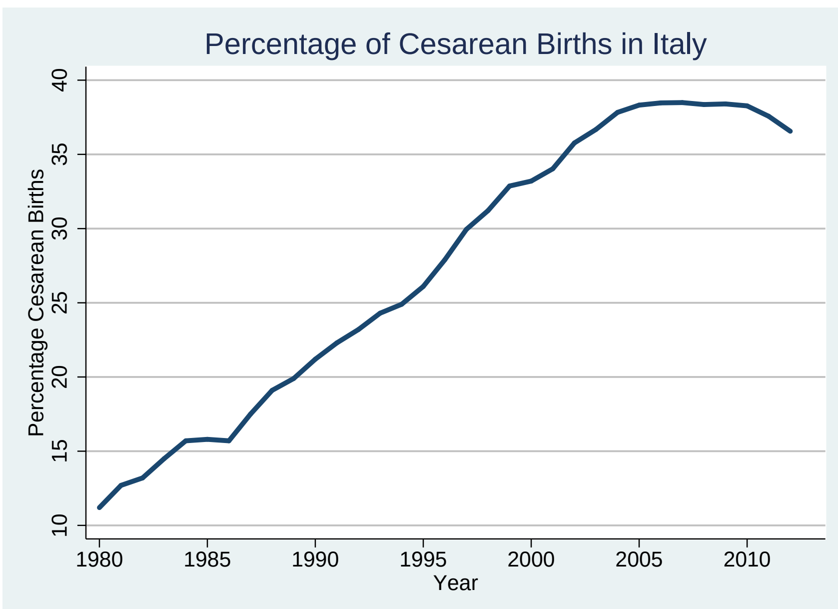

Figure 1: Evolution of Cesarean Rates in Italy. 1980-2012. Data Source: Health For All Database, 2013.

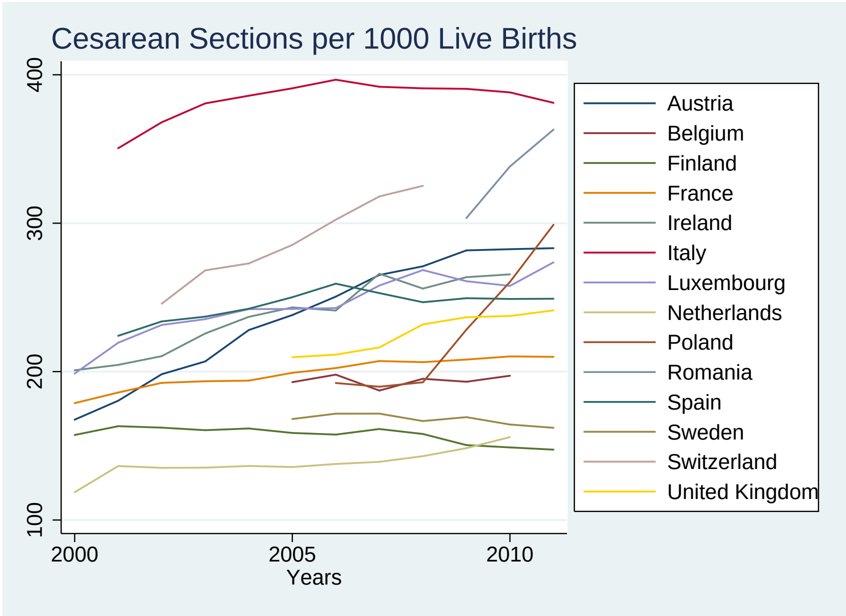

Figure 2: Cesarean Section Rates across Countries. Data Source: European Health for All Database, 2013.

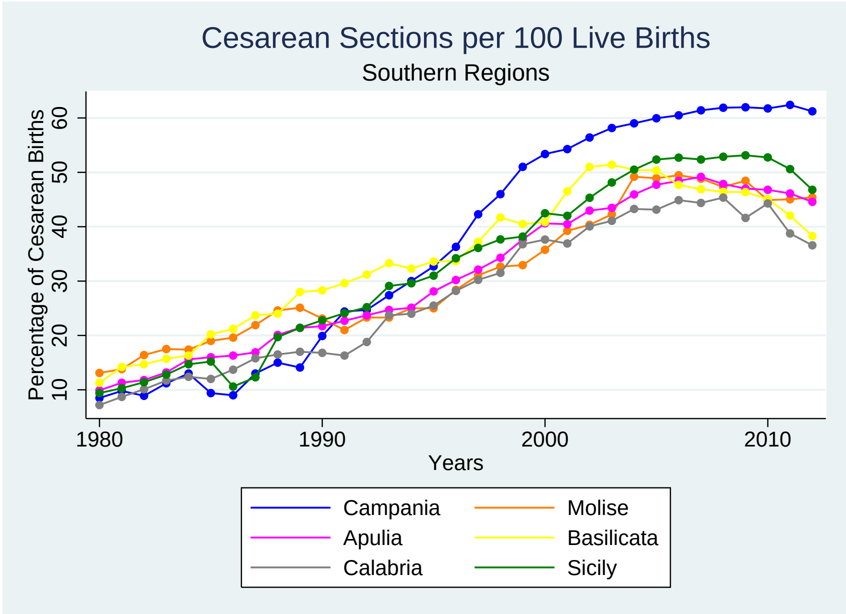

Figure 3: Cesarean Births per 100 Live Births in the South. Data Source: Health for All - Italy database.

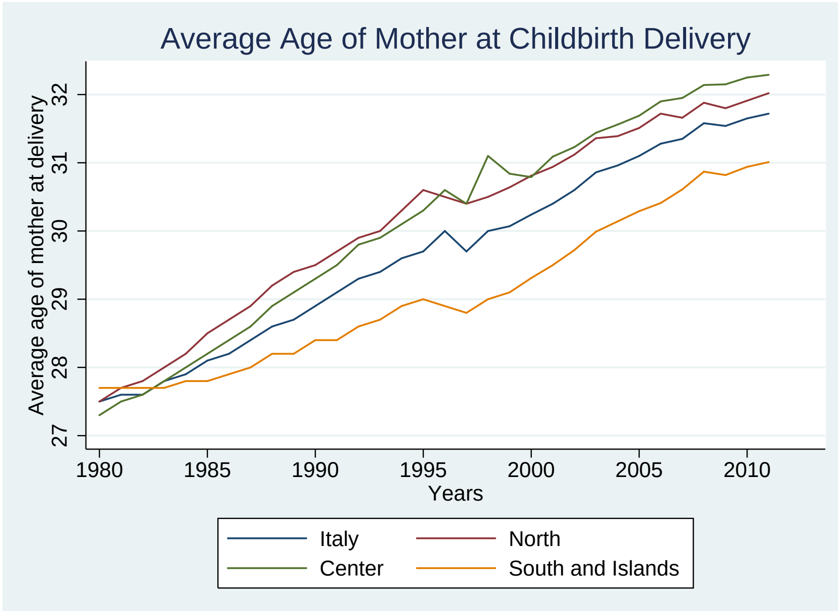

Figure 4: Average Mother's Age at Childbirth Delivery by Broad Geographical Area. The blue line shows the trend in average mother's age at childbirth delivery in Italy. The red line refers to the North, the green line refers to the Center and the yellow line refers to the South and the Islands. Data Source: Health for All - Italy database.

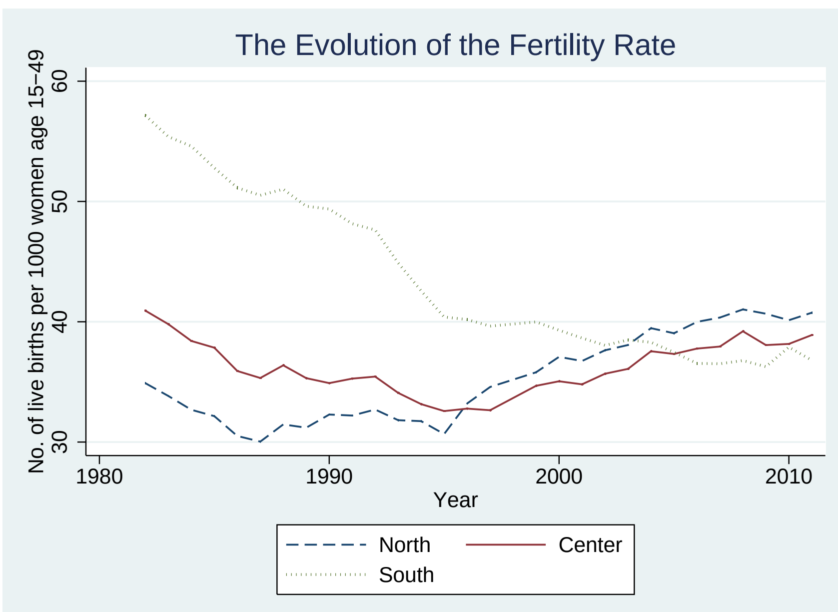

Figure 5: The Evolution of the Fertility Rate over Time across Broad Geographical Areas. The figure plots the number of live births per 1000 women age 15-49 from 1980 to 2011 for the three broad geographical areas: the North (dashed line), the Center (solid line) and the South (dotted line). Data Source: Health for All - Italy database.

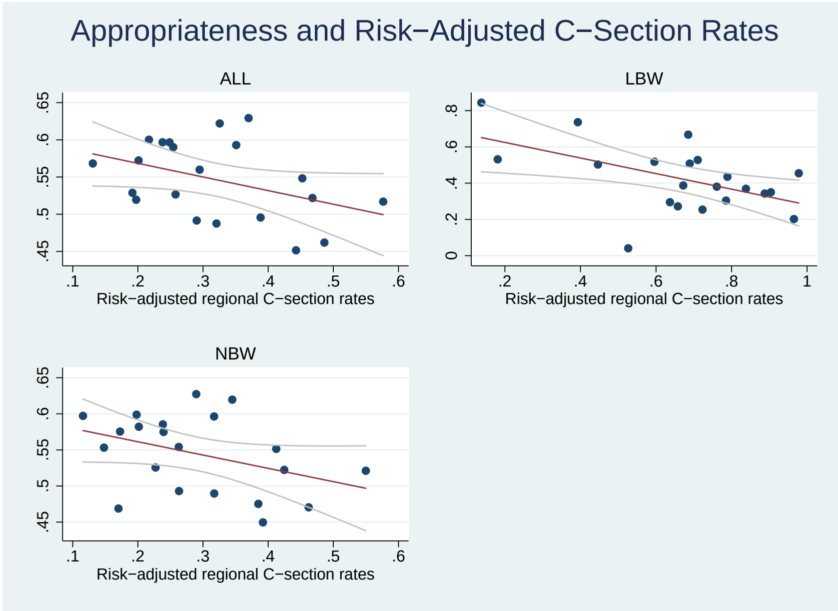

Figure 6: Relation between Average Appropriateness and Risk-Adjusted Regional Cesarean Section Rates for Cesarean Births. Each plot shows the relation between average appropriateness and regional risk-adjusted cesarean rates for all birth-weights (ALL), low-birthweight births (LBW) and normal-birthweight births (NBW).

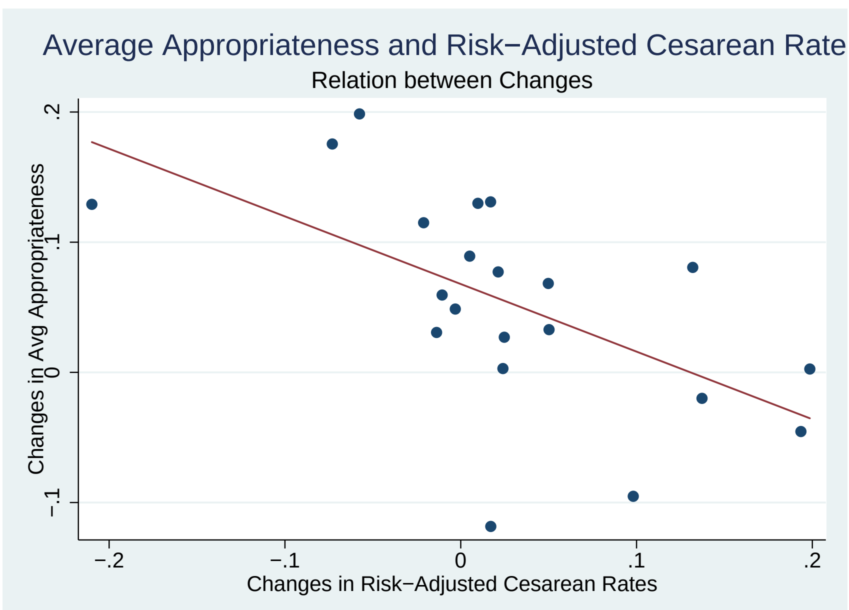

Figure 7: Relation between Changes in Average Appropriateness and Changes in Risk-Adjusted Cesarean Rates across Regions for Cesarean Births. The figure plots the relation between changes in average appropriateness and risk-adjusted cesarean rates across regions. The time-varying measure of appropriateness and the time-varying measure of risk-adjusted cesarean rates are obtained from a logistic model where all coefficients are allowed to vary between the two time periods 1998-2002 and 2003-2005 (see text for more details).

Appendix

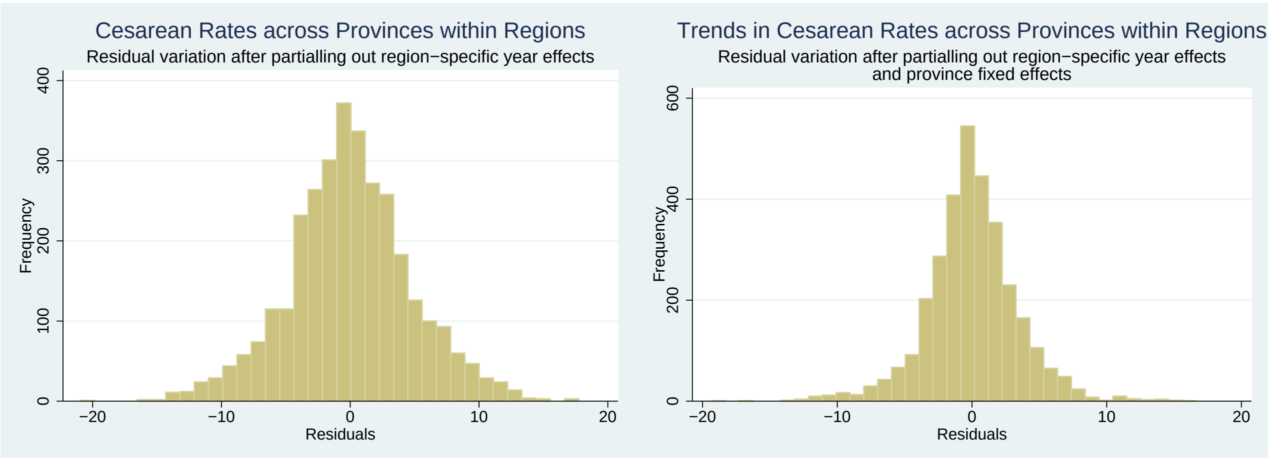

Figure A.1: Within-Region Variation in the Use of Cesarean Sections. The plot on the left shows the histogram of the residuals from a regression of province-by-year unadjusted cesarean rates on region-by-year fixed effect. The plot on the right shows the histogram of the residuals from a regression of province-by-year unadjusted cesarean rates on province fixed effects and region-by-year fixed effects. Data Source: Health for All - Italy database. Years: 1980-2012.