FERTILITY RATE, USE OF CESAREAN DELIVERY, AND THE ROLE OF INFORMATION GAP: EVIDENCE FROM TAIWAN

Ke-Zong Ma

A dissertation submitted to the faculty of the University of North Carolina at Chapel Hill in partial fulfillment of the requirement for the degree of Doctor of Philosophy in the Department of Health Policy and Administration, School of Public Health.

Chapel Hill
2007

Approved by:

Edward C. Norton, Ph.D. (Advisor)

Shin-Yi Chou, Ph.D. (Reader)

David K. Guilkey, Ph.D. (Reader)

Dean M. Harris, J.D. (Reader)

Shoou-Yih Daniel Lee, Ph.D. (Reader)

ABSTRACT

KE-ZONG MA: Fertility Rate, Use of Cesarean Delivery, and the Role of Information Gap: Evidence from Taiwan
(Under the direction of Edward C. Norton, Ph.D.)

Economists are interested in the financial incentives affecting health care providers. More specifically, the case of clinically unnecessary cesarean delivery (c-section) often attracts their attention because it is invasive and has an increasing trend in many developed and developing countries. Empirically, changes in the fertility rate can serve as an exogenous shock to identify the impact of financial pressure on the use of c-sections. However, the validity of such studies could be questioned for the endogeneity problem because the increasing use of c-sections may also reflect higher social value of newborns as the fertility rate decreases, and this alternative explanation leaves open the question of the magnitude of inducement due to the rapidly declining fertility rate.

To better understand the effect of the shrinking fertility on the choice of the delivery modes, this study takes advantages of the dramatic decline fertility in Taiwan from 1996 to 2004 to examine whether an exogenous and negative income shock to ob/gyns may affect the use of c-sections, which has a higher reimbursement rate under Taiwan's National Health Insurance system than vaginal deliveries. To conduct a systematic population-based study, the primary data are obtained from the 1996 to 2004 National Health Insurance Research Database in Taiwan. The main research hypothesis is that a negative income shock to ob/gyns would cause ob/gyns to provide more c-sections on less medically-informed individuals to make up their income difference. Moreover, this study will also examine the spillover of the declining fertility by testing the effect of negative income shock on the use of inpatient tocolysis.

Results first show that the declining fertility or the increasing number of ob/gyn per 100 births lead to an increase in the probability of having c-sections, while the marginal effects are small but highly significant. Findings from multinomial logit models further suggest that maternal request contributes significantly to the increasing use of c-sections, and such requests possibility stemmed from anxiety or fear about the safety of themselves or their baby given the lower and lower fertility rate. For the role of health information gap, the marginal effects of the interaction terms "fertility × information" and "ob/gyn per 100 births × information" are not statistically significant in the empirical specifications, i.e., the inducement effect does not exist in c-sections.

The empirical test of the spillover effect on tocolytic hospitalization revealed that ob/gyns, hospitals, and clinics could recoup the income loss due to declining fertility by providing more inpatient tocolysis. The negative income effect is especially stronger for regional or district hospitals, teaching hospitals, and private non-profit hospitals.

Because of the unusual, exogenous occurrence of fertility decline in Taiwan and the use of detailed medical information and crucial demographic attributes of pregnant women, this dissertation research will be able to avoid the endogeneity problem that has threatened the validity of existing health economics research on c-sections. It will also provide more accurate estimates of physicians' ability to induce demand because of their expertise in medical knowledge. Results of this study, therefore, will contribute to the literature and provide policy recommendations with regard to physician behavior and practice.

To my family and friends, with love and appreciation

ACKNOWLEDGEMENTS

My wonderful dissertation committee provided invaluable guidance for this study. My deepest gratitude goes to my dissertation advisor and committee chair, Dr. Edward C. Norton, whose responsiveness, innovation, advice, and mentoring, had made the completion of this dissertation a rewarding and truly enjoyable experience in my life. I also sincerely thank other committee members: Dr. Shin-Yi Chou, Dr. David K. Guilkey, Dr. Dean M. Harris, and Dr. Shoou-Yih Daniel Lee. Each of them contributed uniquely to the evolution of this dissertation, and I want to further express my appreciation to their support and encouragement during my study.

I am also grateful to my thesis advisor, Dr. Yiing-Jenq Chou. He helped me to get access to the NHRID and provided me research space as well as administrative support during my stay in Taiwan. My appreciation also goes to Dr. Hsien-Ming Lien for his kind help in STATA programming. Finally, research funds from the Doctoral Research Travel Award, HPAA Global Health Travel Grant, Smith Graduate Research Grant, GPSF Research Travel Award, and the Dissertation Fellowship for ROC Students Abroad by the Chiang Ching-kuo Foundation for International Scholarly Exchange are all of critical importance in completion of this dissertation.

TABLE OF CONTENTS

Page

LIST OF TABLES……………………………………………………………………………..x

LIST OF FIGURES…………………………………………………………………………xiii

LIST OF ABBREVIATIONS……………………………………………………………..…xiv

Chapter 1 INTRODUCTION………………………………………………………………..1

Chapter 2 BACKGROUND AND SIGNIFICANCE…………………………………….....10

2.1 Physician Financial Incentives and Cesarean Delivery………………………………..10

2.2 Health Information Gap and the Use of Cesarean Delivery…………………………...…12

2.3 General Background on Fertility in Taiwan……………………………………………16

2.4 National Health Insurance in Taiwan…………………………………………………..18

2.5 General Background on Cesarean Delivery in Taiwan………………………………...20

2.6 The Use of Inpatient Tocolysis…………………………………………………….....23

2.7 Contributions of This Study……………………………………………………………...25

Chapter 3 DATA AND MEASUREMENT…………………………………………….....29

3.1 Data Sources…………………………………………………………………………...29

3.2 Study Population……………………………………………………………..............30

3.3 Measurements………………………………………………………………………….31

3.3.1 Dependant variable…………………………………………………………………31

3.3.2 Identifying markets and measuring fertility rate…………………………………32

3.3.3 Identifying the health information gap……………………………………...…34

3.3.4 Identifying the use of inpatient tocolysis……………………………………....35

3.3.5 Clinical indicators……………………………………………………………..36

3.3.6 Nonclinical indicators…………………………………………………….......38

3.4 Sample Statistics……………………………………………………………….…39

Chapter 4 EMPIRICAL SPECIFIATIONS……………………………………………44

4.1 Identification Strategy……………………………………………………………44

4.2 Research Hypotheses……………………………………………………………..45

4.3 Probit Model……………………………………………………………………...45

4.4 Multinomial Logit Model………………………………………………………...50

4.5 Discrete Factor Model………………………………………………………….…53

4.6 Estimation of the Spillover Effect………………………………………………...55

4.7 Robustness Check………………………………………………………………,,,58

Chapter 5 EMPIRICAL RESULTS…………………………………………………...60

5.1 Descriptive Statistics……………………………………………………………...61

5.1.1 Individual characteristics………………………...61

5.1.2 Distribution of ob/gyn and hospitals/clinics characteristics……........................62

5.2 Effects of Declining Fertility on the Use of C-sections………………………………62

5.2.1 Probit model…………………………………………………………..……62

5.2.2 Robustness checks………………………………………………………….64

5.2.3 MNL model…………………………………………………………………65

5.2.4 Summary of results………………………………………………………....66

5.3 The Role of Information Gap and the Inducement Effects……………………………66

5.3.1 Probit model………………………………………………………………...66

5.3.2 MNL model…………………………………………………………………66

5.3.3 Summary of results…………………………………………………………67

5.4 Discrete Factor Model……………………………………………………………….68
5.4.1 Probit model with two points of support…………………………………………68
5.4.2 MNL model with two points of support…………………………………………68
5.4.3 Summary of results……………………………………………………………69
5.5 Test of the Spillover Effects on Inpatient Tocolysis…………………………………...70
5.5.1 Estimations of spillover effect inpatient tocolysis………………………………70
5.5.2 Comparison of coefficients on $\Delta BITE$ with respect to different institutional factors……………………………………………………………………………..71
5.5.3 Summary of results……………………………………………………………72
Chapter 6 DISCUSSIONS……………………………………………………….......110
6.1 Summary of Findings……………………………………………………………110
6.2 Conclusion and Policy Implications……………………………………………112
6.3 Limitations………………………………………………………………………115
6.4 Directions for Future Research…………………………………………………117
REFERENCES……………………………………………………………………..120

LIST OF TABLES

Table **Page**

Table 1. Number and rates of birth and c-section in Taiwan, 1996-2004…………………………8

Table 2. Selection criteria for inpatient tocolysis……………………………………………...41

Table 3. List of complications for c-sections…………………………………………………41

Table 4. Summary statistics of the use of vaginal deliveries, c-sections, and CDMR, 1996-2004……………………………………………………………………...42

Table 5. Sources of identifying variations……………………………………………………43

Table 6. Summary statistics of patients by delivery modes, 2000-2003…………………………73

Table 7. Summary statistics of patients by health information gap (defined by occupational status), 2000-2003……………………………………………………………………...……74

Table 8. Summary statistics of patients by health information gap (defined by insurable wage), 2000-2003………………………………………………………………………...75

Table 9. Summary statistics of hospital and clinic characteristics, 1996-2004…………………..76

Table 10. Summary statistics of ob/gyn characteristics, 1996-2004…………………………..…77

Table 11. The effect of declining fertility on ob/gyns' revenue…………………………………78

Table 12. The effect of declining fertility on hospitals' and clinics' revenue……………………………………………………………………........……78

Table 13. Volumes and LOS of tocolysic hospitalizations, 1996-2004……………..…………………………………………………………..79

Table 14. Total and mean revenues of tocolysic hospitalizations, 1996-2004……………………………………………………………...………79

Table 15. Probit Estimates of the effect of fertility on the probability of having c-sections (for Equations (1) and (2))…………………..…………………………………………...80

Table 16. Robustness check for Table 15……………………………………………………...81

Table 17. Multinomial logit (MNL) estimates for equation (5): the effect of declining fertility on the probability of having c-sections and CDMR (Base outcome: vaginal delivery)…………....82

Table 18. Multinomial logit (MNL) estimates for equation (5): the effect of declining fertility on the probability of having c-sections and CDMR (Base outcome: vaginal delivery)……………83

Table 19. Probit estimates for equation (3): the effects of declining fertility and health information gap on the probability of having c-sections (Base outcome: vaginal delivery)…….84

Table 20. Probit Estimates for Equation (4): the effects of declining fertility and health information gap on the probability of having c-sections (Base outcome: vaginal delivery)…….86

Table 21. MNL estimates of the effects of declining fertility and health information gap (Base outcome: vaginal delivery; Comparison group: female physicians and female relatives of physicians; Treatment group: other women)…………..…………………………………....88

Table 22. MNL estimates of the effects of declining fertility and health information gap (Base outcome: vaginal delivery; Comparison group: female physicians and female relatives of physicians; Treatment group: other women)…………………………………………………………………………....90

Table 23. MNL estimates of the effects of declining fertility and health information gap (Base outcome: vaginal delivery; Comparison group: high socioeconomic status women; Treatment group: low socioeconomic status women)………………………………………………………..………………………92

Table 24. MNL estimates of the effects of declining fertility and health information gap (Base outcome: vaginal delivery; Comparison group: high socioeconomic status women; Treatment

group: low socioeconomic status
women)……………………..……………………………………………………………94

Table 25. Discrete Factor Model with Two Points of Support for Equation (1) and (2)………...96

Table 26. Discrete Factor Model with Two Points of Support for Equation (5)…………………98

Table 27. Discrete Factor Model with Two Points of Support for Equation (5)…………………99

Table 28. Discrete Factor Model with Two Points of Support for Equation (3)………………..100

Table 29. Discrete Factor Model with Two Points of Support for Equation (4)………………..102

Table 30. Discrete Factor Model with Two Points of Support for Equation (3) (Base outcome: vaginal delivery; Comparison group: female physicians and female relatives of physicians; Treatment group: other women)……………………………………………………….....104

Table 31. Discrete Factor Model with Two Points of Support for Equation (4) (Base outcome: vaginal delivery; Comparison l group: high socioeconomic status women; Treatment group: low socioeconomic status women)…………………………………………………………….105

Table 32. Discrete Factor Model with Two Points of Support for Equation (3) (Base outcome: vaginal delivery; Comparison group: female physicians and female relatives of physicians; Treatment group: other women)………………………………………………………..106

Table 33. Discrete Factor Model with Two Points of Support for Equation (4) (Base outcome: vaginal delivery; Comparison group: high socioeconomic status women; Treatment group: low socioeconomic status women)…………………………………………………………….107

Table 34. First difference model for the spillover effect on inpatient tocolysis……………......108

Table 35. Comparison of coefficients on $\Delta BITE$ from the first difference models…………….…109

LIST OF FIGURES

Figure **Page**

Figure 1. Trend of fertility in Taiwan……………………………………………………….…..7

Figure 2. Trend of c-section rates in Taiwan……………………………………………………9

LIST OF ABBREVIATIONS

BNHI	Bureau of National Health Insurance
DOH	Department of Health
DD	Difference-in-Differences
DRG	Diagnostic Related Group
FFS	Fee-for-service
GFR	General Fertility Rate
HHI	Herfindahl-Hirschman Index
ICD-9-CM	International Classification of Disease, 9th Revision, Clinical Modification
IIA	Independence of Irrelevant Alternatives
LOS	Length of Stay
MAR	Medical Arm Race
MNL	Multinomial Logit
NHI	National Health Insurance
NHIRD	National Health Insurance Research Database
NHRI	National Health Research Institute
NIH	National Institutes of Health
OECD	Organization for Economic Co-operation and Development
PPS	Prospective Payment System
PTL	Pre-term Labor
VBAC	Vaginal Birth after Cesarean
WHO	World Health Organization

Chapter 1: INTRODUCTION

Cesarean section (c-section) rates are one of the major measures to judge health system performance because policymakers and health care advocates are concerned about the high use of medically unnecessary c-sections. High c-section rates are an increasing concern throughout the world. A number of reports have documented complex factors determined the increasing trend of c-section rates in both developed and developing countries over the last few decades (Menacker and Curtin, 2001; Menacker, 2001; Althabe, Sosa, Belizen, Gibbons, Jacquerioz, and Bergel, 2006).

Since the 1980s, economists also have been interested in the growth of c-sections. Their studies mainly focus on the financial incentives of c-sections, such as insurance types, physician to population ratios across areas, and the fee differences between c-sections and vaginal deliveries, to reduce medically unnecessary c-sections. However, the validity of most of these studies can be questioned for methodological issues, especially the endogeneity problems. For instance, the population to physician ratio could be endogenous because the causality between physician supply and utilization can run both ways (Dranove and Wehner, 1994). Besides, the insurance coverage type may not be exogenous because there may be omitted characteristics by payer class that are correlated with the c-section rate (Gruber and Owings, 1996). Other major factors such as misspecification of the estimation equation, patient migration, reduced time cost, or increased quality may also introduce endogeneity.

Finding exogenous variations is the key to drawing causal inferences between the financial environment and the use of c-sections. Changes in the fertility rate, one of the inducement-type incentives, can serve as an exogenous shock to identify the effects of financial pressures facing health care providers on the c-section rate, because obstetricians may influence where and how children are born, however, it is implausible to think that they can substantially affect the number of births (Dranove et al., 1994). One well-known study by Gruber and Owings (1996) found that declining fertility would lead obstetricians and gynecologists (ob/gyns) to substitute from vaginal deliveries toward c-sections, which are traditionally a more highly reimbursed and profitable alternative considering the product intensity and time (Gruber et al., 1996; Gruber, Kim, and Mayzlin, 1999). Moreover, the higher reimbursement levels are not necessarily justified by increased physician inputs. According to Gruber et al. (1996), In terms of just the time investment, c-section is much more efficient for ob/gyns; unlike vaginal delivery, c-sections can be scheduled in advance, and they can often take less time than a vaginal delivery with extended labor. Of course, c-section is a more difficult procedure. However, the 1993 revision of the resource-based relative value scale (RBRVS), which measures physician workloads by the product intensity and time, concluded that the workload for vaginal delivery is actually higher than that of c-section (Keeler and Brodie, 1993). The decline in fertility rate may represent a shock that shifts the demand for obstetrics services inward and should increase the income pressure of ob/gyns, if the number of ob/gyns continues unabated.

A rapidly declining fertility rate, on the other hand, might change women's preferences of delivery modes (Paranjothy and Thomas, 2001), and this generates another possible explanation to the correlation between the fertility and the c-section rate. Further, many studies have shown that the increasing cesarean delivery on maternal request (CDMR) contributes to the increase in the rate of c-sections (Mancuso, Vivo, Fanara, Settineri, Triolo, and Giacobbe, 2006). CDMR is defined as a c-section for a singleton pregnancy on maternal request at term in the absence of many medical or obstetrical indications. CDMR is a subset of elective c-sections. Elective c-sections includes a planned c-section for a wide range of maternal and fetal indications and is generally distinguished from emergency c-section and "labored" c-section after planned vaginal delivery (PVD).

Women's desire to deliver by c-sections plays a significant role in the final decision regarding the method of delivery. The general perception is that a c-section is much safer now than in the past, and a c-section may avoid some negative maternal outcomes with vaginal delivery, such as the stress incontinence, sphincter damage, and sexual dysfunction. The increasing use of c-sections may also reflect higher social value of newborns as fertility rate decreases. In Chinese society, the tremendous importance of having a healthy baby given the low fertility rate provides much of the impetus for having a c-section. Many women request a c-section because they believe it is to be easier on the baby, more modern, and perhaps easier on themselves. Some also believe that babies delivered by c-section will be more intelligent (Cai, Marks, Chen, Zhuang, Morris, Harris, 1998; Wu, 2000). Thus, omitting patient's preferences could bias the estimation on the propensity for the use of c-sections, and the absence of appropriate measure of patient's choice information will further makes the impact of declining fertility rate on the use of c-sections unclear.

These alternative explanations leave open the question of the magnitude of inducement on c-sections due to rapidly decreasing fertility rate. To better understand the impact of shrinking fertility on the choice of the delivery mode, this study will develop a comprehensive framework for the use of c-sections and apply this framework to the case in Taiwan by addressing the following three research questions:

First, does the decline in the fertility rate increase the use of c-sections? As noted in previous studies, ob/gyns may induce more lucrative c-sections through an income effect because their income from obstetrics is parallel to the fertility rate (McGuire and Pauly, 1990; Gruber et al., 1996). This study takes advantage of the dramatically declining fertility in Taiwan to examine whether an exogenous and negative income shock to ob/gyns may affect the use of c-sections. The number of live births in Taiwan was 325,545 in 1996, and it decreased to 217,000 in 2004 (see Figure 1), giving Taiwan one of the lowest-fertility rates among developed countries. The dramatic change in number of live births in Taiwan over the 1996-2004 periods could be a significant and unanticipated change to ob/gyns, and more formally, a negative and exogenous income shock to them. The c-section rate in Taiwan has ranged between 32 to 34 percent since 1996 (see Table 1 and Figure 2), which is relatively high and stable compared to most other countries. Further, the rates of CDMR in Taiwan increased from 2 percent in 1997 to 3.5 percent in 2001 (NIH, 2006), with higher increase in women 35 an older.

Given alternative explanations of the correlation between fertility and the c-section rate, finding a significant effect from the first research question does not necessarily mean there is demand inducement, and vice versa. This gives rise to the second research question: **does the rapidly declining fertility rate increase the use of c-section, conditional on patients' professional background and presumed access to health information?** Empirically, this study employs a difference-in-differences approach to test whether the effects of declining fertility on the choice of delivery modes differ by the access to health information. Imperfect information has been recognized as a key feature of health care markets since Arrow's seminal study in 1963, and a few studies have shown that the level of inducement could be higher for poorly informed consumers (Kenkel, 1990). Further, it is possible that women in localities with larger declines in fertility are more likely to be induced to get a c-section than those in localities with smaller declines in fertility. Therefore, by comparing the likelihood of undergoing a c-section on medically-informed individuals (female physicians and female relatives of physicians, or high socioeconomic status women) versus other women with respect to variations in decreasing fertility across subregions in Taiwan during the 2000-2003 period, the magnitude of inducement can be more precisely estimated. Conceptually,

Inducement Effect = [(c-section)$_{NI, LF}$ − (c-section)$_{NI, HF}$] − [(c-section)$_{I, LF}$ − (c-section)$_{I, HF}$]

where

NI: not-medically-informed individuals (i.e. non-physician and not relative of physicians or low SES women)

I: medically-informed individuals (i.e. female physicians and their relatives and high SES women)

LF: localities with lower fertility

HF: localities with higher fertility

Taiwan instituted a National Health Insurance (NHI) program that provides universal health insurance coverage to the entire population in March 1995. Moreover, the rapidly declining fertility rate also provides a compelling setting to examine whether a plausibly exogenous and negative income shock could cause ob/gyns to provide more c-sections. This study will use longitudinal insurance claims of NHI receipts from 1996 to 2004. The data set contains rich clinical information in both provider and patient levels, and the detailed information thus makes it possible to derive the key variables for this study.

The third research question of this study is: **is there evidence of increased use of other inpatient obstetric and gynecological services as ob/gyns' response to declined fertility rates?** Although few studies based on the U.S. experience have revealed a statistically significant correlation between the fertility rate and the use of c-sections, a criticism of previous research is that these results do not preclude other income-recovery strategies (McGuire, 2000). For example, ob/gyns could have changed the level of demand inducement for other obstetrics or gynecological services of their practices as well.

To answer this question, this study uses a longitudinal panel of ob/gyns and hospitals under

NHI to examine the effects of declining fertility on ob/gyn's and hospital's behavior in provider practice level from 1996 to 2004, given the fact that revenue from obstetric deliveries often contribute a considerable share of their total inpatient revenue. The study then tests for the spillover effect of declining fertility focusing on the use of inpatient tocolysis. Tocolysis refers to the delaying or inhabitation of labor during the birth process. Tocolytic treatment is frequently administrated to women presenting with preterm labor (PTL) symptoms who are without conditions contradictionary to pregnancy prolongation (Ambrose, Rhea, Istwan, Collins, and Stanziano, 2004). In obstetric care, tocolysis treatment is widely used in the management of preterm labor, and inpatient tocolysis also accounts for greater hospital days and hospital charges. Importantly, with older marriage and childbearing age as well as increasing utilization of artificial reproductive technology services in Taiwan in recent years, the demand for tocolysis has been increasing and thus provide ob/gyns another income-recovery avenue in order to alleviate the financial pressure caused by less and less number of newborns.

Figure. 1 Trend of fertility in Taiwan

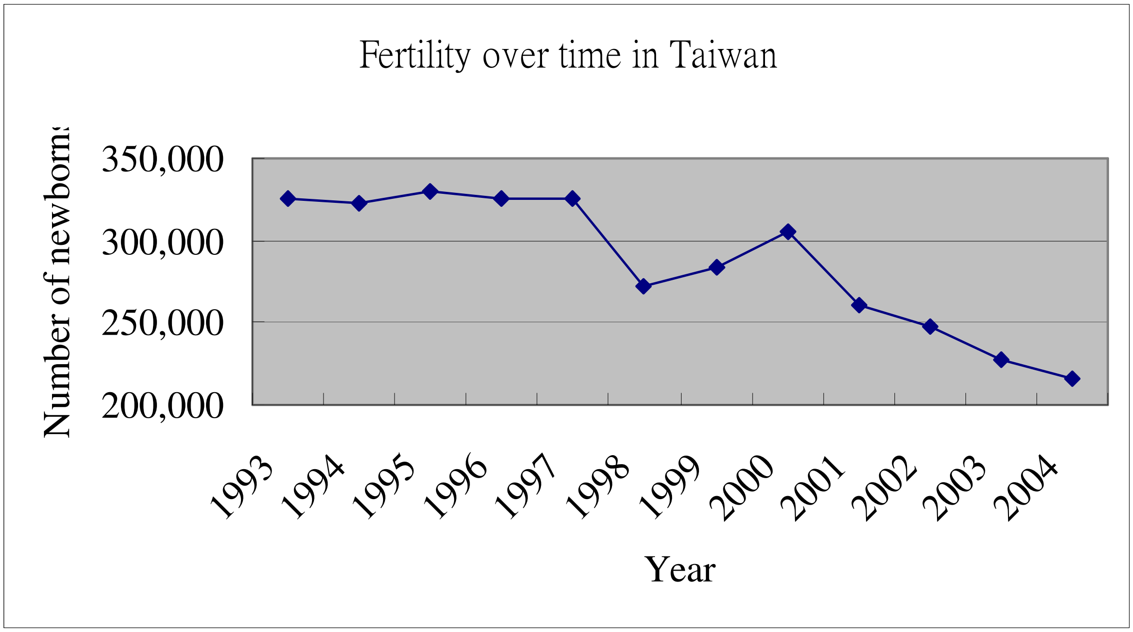
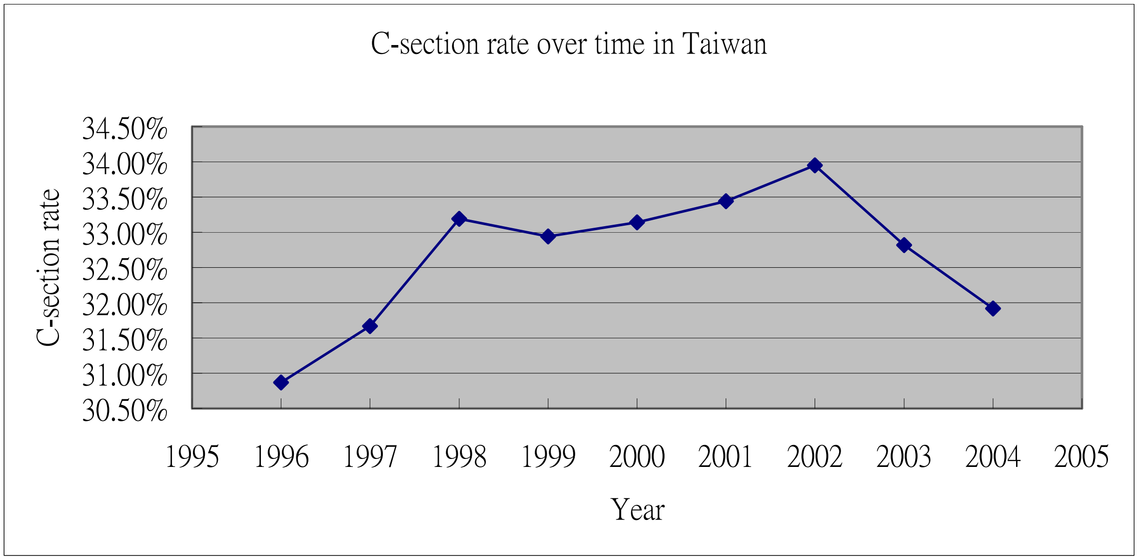


Table 1. Number and rates of birth and c-section in Taiwan, 1996-2004

Year	Number of live births	Total fertility rate	General fertility rate	C-section rate
1996	325,545	1.760	54	32.96
1997	326,002	1.770	53	32.65
1998	271,450	1.465	43	33.09
1999	283,661	1.555	45	33.09
2000	305,312	1.680	48	34.47
2001	260,354	1.400	41	32.74
2002	247,530	1.340	39	33.10
2003	227,070	1.235	36	32.67
2004	216,419	1.180	34	32.74

Notes: number of newborns and fertility rates data are from the Department of Household Registration Affairs, Taiwan. The c-section rates data are from the Department of Health, Taiwan. Total fertility rate is the average number of children that would be born to a woman over her lifetime if she were to experience the current age-specific fertility rates through her lifetime. It is obtained by summing the age-specific rates for a given time-point. General fertility rate measures the number of births per 1,000 women aged 15 to 45.

Figure 2. Trend of c-section rates in Taiwan



Chapter 2: BACKGROUND AND SIGNIFICANCE

2.1 Physician Financial Incentives and Cesarean Deliveries

Health economists have been interested in the asymmetric information in health care market since Arrow's seminal study. According to Arrow (1963), the collection and evaluation of diagnostic information can be performed only by trained physicians, and cannot be easily separated from the provision of medical treatment. Asymmetric information plays an important role in explaining the physician—patient relationship and the inducement incentives of physicians. The physician-induced demand hypothesis is essentially that physicians engage in some persuasive activity to shift the patient's demand curve in or out according to the physician's self interest. Patients have incomplete information about their condition, and may be vulnerable to this advertising-like activity (McGuire, 2000).

A very large part of the literature in health economics was on the discussion on the inducement models. McGuire and Pauly (1991) developed a general model of physician behavior encompassing the two benchmark cases of profit maximization and target income behavior. Their model showed that the induced demand hypothesis is simply the implication of a model where income effects dominate substitution effects. The income and substitution effects are analogous to the Slutsky decomposition of the income and substitution effects of a price change (Yip, 1998).

Although the impact of financial incentives on the use of c-sections has been investigated in a few earlier reports (Stafford, 1990; Tussing and Wojotowycz, 1992; Keeler and Brodie, 1993), their specifications may lead to biased assessments because of omitting provider and patient heterogeneity. Gruber and Owings (1996) expanded McGuire and Pauly's model and stated that an income effect should lead ob/gyns to induce demand for the more lucrative c-sections over vaginal deliveries by providing more convincing evidence. Using data over the period 1970-1982 in the U.S., they found that a 10 percent fertility drop corresponds to an increase of 0.6 percentage points in the probability of undergoing a c-section. Nevertheless, McGuire (2000) argued that these results do not preclude other income-recovery effects. For example, ob/gyns could have changed the level of demand inducement for the gynecological side of their practices as well.

A more recent study by Gruber, Kim, and Mayzlin (1999) further examined the effect of higher Medicaid fee differentials on the use of c-sections over the period of 1988-1992. Their results showed that larger fee differentials between c-sections and vaginal deliveries for the Medicaid program leads to higher c-section rates. Especially, this study provides empirical evidence that cutting reimbursement for c-sections could lower the intensity of treatment of childbirth.

Evidence from an empirical study in Taiwan is also in accordance with previous reports. Chou, Liu, and Chen (2002) analyzed the birth and death certificates in Taiwan from 1996 to 1998 and they revealed that the probability of undergoing a c-section is higher within more competitive markets. Because the reimbursement fees for c-sections are also higher than those for vaginal deliveries, there were financial incentives for hospitals to perform more c-sections under competition pressure. Their study also controlled for fixed hospital and regional effects to mitigate the potential endogeneity of unobserved individual health conditions, and thus provided more consistent estimations.

More importantly, their research may be easier to generalize to other countries with a single-payer health system, because in the U.S. the presence of multiple payers increases the difficulty to collect complete information and studies on the financial incentives for the use of c-sections are usually derived based on data of one large public payer (e.g., Medicaid). Furthermore, there have been studies (Epstein and Wesissman, 1989; Gruber et al., 1999) indicating that different insurance types may lead to different c-section rates, especially when private payers were involved.

2.2 Health Information Gap and the Use of Cesarean Delivery

As discussed in the previous section, the basic premise behind physician-induced demand is that physicians may exploit the information gap between themselves and their patients. Therefore, more physician-induced demand should be observed where the information gap is greater. For example, Bunker and Brown (1974) reasoned that the smallest information gap should be between physicians and patients who were themselves physicians or their families. Moreover, Pauly and Satterthwaite (1981) has also predicted that inducement effects should be largest for the least informed consumers and those with low income in big cities. Hay and Leahy (1982) further developed a more theoretical framework about physician inducement and consumer information gap, and their model posited that demand-inducing physicians will provide more services, ceteris paribus, to their medically uninformed patients.

From another point of view, the care-seeking behavior and utilization patterns of the families of health personnel may provide useful insights into defining the appropriate use of health care and the quality of that care, because they represent medically savvy consumers and are familiar with the health care system. Previous findings have indicated that physicians may treat their peers, and the relatives of their peers differently than other patients, because the treating physicians may be under stronger pressure from these informed patients (Huang, Morlock, Lee, Chen, and Chou, 2005).

With regard to the use of c-sections, physicians have professional knowledge of the health risks and benefits associated with the different methods of delivery. Risks associated with vaginal deliveries include stress incontinence, anal sphincter damage, and sexual dysfunction. On the other hand, c-sections may lead to higher maternal mortality, anesthesia accidents, damage to blood vessels, accidental extension of the uterine incision, damage to the urinary bladder and other organs, accidental lacerations, problems with nursing, and respiratory distress in infants. It is to be expected, that physicians would act in a rational and appropriate manner when considering their own delivery. Moreover, physicians, medically informed patients, can serve as role models when choosing delivery methods or treatments. Female relatives of physicians are also expected to have more knowledge about the lack of benefit with medically unnecessary c-sections.

A study from Australia (Gamble, Health, and Creedy, 2001) indicated that women who prefer c-sections were more anxious, generally poorly informed of the risks of this procedure, and overestimated the safety of this procedure. It is plausible that ob/gyns may overplay the lack of information of these women to their advantages, but Gamble et al.'s study did not provide direct evidence between the information gap and the possibility of demand inducement on the use of c-sections.

A more recent study by Chou, Huang, Deng, Tsai, Chen, and Lee (2006) stated that, when compared to the severe maternal and neonatal morbidity and mortality which may result from c-sections, some women who have an uncomplicataed delivery may overcome their fears of vaginal deliveries and avoid putting themselves and their babies in unnecessary danger by choosing c-sections if they are adequately informed of the risks involved with c-sections. Assuming that physicians and their relatives are well informed of the risks and benefits associated with the different methods of delivery, Chou et al.'s (2006) research also found that female physicians and female relatives of physicians were significantly less likely to undergo a c-section than other high socioeconomic status women, adjusted for clinical and non-clinical factors.

However, the definition of the health information gap in Chou et al.'s (2006) study is arguable. Although physicians' dominance in the determination of medical services that are needed for patients is generally true for almost all diseases, the delivery of a baby is not quite like treating a disease because the degree of information asymmetry between physicians and patients may be lower for deliveries than for other medical care (Lo, 2003). Ob/gyns may have considerable control over whether a delivery will be completed vaginally or via c-section, as well as the timing of delivery, however, patients still have room to determine whether a c-section is desired. This begs the question—will the occupational status (health professionals vs. non-health professionals) be a good measure of the information gap on the use of c-sections?

Moreover, misclassification may be another source of bias when using the occupational status to measure of the information gap on the use of c-sections in Chou et al.'s (2006) study. Since the household registry could only be linked to those women co-residing with physicians, and family members of physicians are likely to also live in different households, these women may be classified under another group. If this is the case, the true difference between physicians' relatives and other women should be larger than that observed. Besides, some high socioeconomic status women (especially those who are well-educated) could also be medically informed, but they were grouped under not-medically-informed individuals in Chou et al.'s (2006) study.

To further explore the effect of the information gap on the use of c-section, the adjustment of education would have been desirable in such a study if the data on education were available (Lee, Khang, and Lee, 2004; Walker, Turnbull, and Wilkinson, 2004). Well-educated women, not only physicians or their female relatives, are expected to have more health information than other women, and have different attitude toward their mode of delivery as well as less likely to be induced to have medically unnecessary c-sections. In the absence of an absolute gold standard to measure the health information gap, examining women's choice of delivery mode along with educational level differences offers an alternative way in empirical test of the demand inducement on c-sections.

Donati, Grandolfo, and Andreozzi (2003) analyzed the relationship between educational level and mother's preference for vaginal deliveries versus c-sections in Italy, where the c-section rate was 33.2 percent in 2000. Their results showed a significant association between women's high level of education and low preference of surgical delivery. In South Korea, another country also with high c-section rates, Lee et al.'s (2004) research showed that, compared with middle-school or high-school graduates, collage graduates had a significantly low level of agreement with the statement that a c-section is the modern delivery method whereas the vaginal delivery is the past one. They further concluded that education may be the best predictor of the attitudes toward delivery. A more recent study (Lee, Khang, Yun, and Jo, 2005) using the population-based National Fertility and Family Health Survey of South Korea from 1998 to 2000 found that as c-section rates rose by year, the relationship between the use of c-sections and education has been reversed. Moreover, their results indicated that in 2000, relatively low caesarean rates were found in variables that will be more prevalent in the future, such as higher maternal education, higher maternal occupation and residence in big cities.

Another study by Linton, Peterson, and Williams (2004) investigated the effects of maternal characteristics on c-section rates among the U.S. Department of Defense health care beneficiaries, and they found that the higher socioeconomic subgroup (measured by pay grade of the sponsor because maternal education is not available in the data) was generally associated with reduced c-section rates. Those findings all imply that the educational level plays an important role in women's decision of delivery mode, and could serve as a good proxy to measure of the health information gap. Due to data limitation, I use socioeconomic status (more specifically, monthly insurable wage) as a marker of the education level in my empirical analyses, and will have a more in-depth discussion in next chapter.

To summarize, because the effects of the health information gap on demand inducement have rarely been explored (Kenkel, 1990), and few studies have pointed out education and occupation in a health field are associated with more availability of information. Thus, this study will use both occupational status and socioeconomic status (as a proxy of education level) to test the effects of the health information gap on demand inducement of c-sections.

2.3 General Background on Fertility in Taiwan

Fertility trends and patterns in Taiwan are a potentially important component of the analysis. According to Freedman, Chang, and Sun (1994), Taiwan completed the fertility transition between 1956 and 1983, while the total fertility rate fell from 6.51 to 2.16. During the transition period, rapid social and economic change contributed to the decline of the fertility rate. Total fertility rate is the number of children a woman would have from age 15 to age 49 if she were to bear children at the prevailing age-specific rates. From 1986 to 1996, however, the TFR has remained relatively stable and oscillated around 1.70 (Chou and Staiger, 1997).

Since 1971, Taiwan's government has implemented several intensive family planning programs. The objective of these population policies was to improve the acceptance of contraceptive methods and to reduce population growth. The program's birth control methods include health education and counseling on fertility regulation services. The government believes that these programs successfully slowed down the population growth by significantly decreasing the birth rate.

After 1990, however, government population policy underwent a rather dramatic change (The Executive Yuan, 1992). The focus of population policy shifted from reducing population growth to improving population quality. The first four-year plan for the "Promotion of a New Family Planning Program in the Taiwan area" began in July 1990. A second four-year plan followed in 1995. These new programs no longer aimed to slow population growth directly (although "two children is just right" remains the official slogan in the advertisement campaign). Freedman and Freedman (1993) conclude that these policies are relatively neutral with respect to the fertility rate and, therefore, that the overall fertility level was primarily determined by non-government societal influences. Thus, the period after 1990 provides a comparatively stable and smooth study period, with little or no government policy interference regarding the overall population fertility rate.

By 1990, family planning was widespread in Taiwan. In the 1991 Taiwan KAP survey, contraceptive use among married women aged 20-39 reached 80 percent in Taiwan. Abortion was legalized by the Genetic Health Law, enacted in July 1984, and as a result women have full access to this procedure without any restrictions. The 1991 KAP survey also showed that 34 percent of married women aged 22-39 had received an abortion, although all experts think this figure is underreported. Thus, it appears that married women in Taiwan can, to some extent, regulate their own fertility behavior.

Importantly, the net reproduction rate has been below the replacement fertility since 1984, and the total fertility rate has already fallen to only 1.12 births per birth-age woman in 2005, among the lowest in the world. The net reproduction rate is the average number of daughters that would be born alive to a hypothetical cohort of women if they experienced the same age-specific fertility throughout their lives that women in each age group experienced in a given year, or period of years, and if they were also subjected to the mortality rates of the same year or period of years. In Taiwan, the NRR fell to 1.0 in 1983 and to 0.6 in 2003. There are a variety of reasons for the rapidly declining fertility in Taiwan in the past ten years. Postponement of marriage and childbearing age played a critical role in the emergence of low fertility. For example, women's average age at marriage increased from 20 in the 1950s to approximately 28 in 2004, while the average childbearing age was 24.1 in 1983 and increased to 27.4 in 2004. Meanwhile, increasing rate of divorce (e.g., in 2.21% 1990 and 5.47% in 2004) and female labor force participation (e.g., 44.50% in 1990 and 47.71% in 2004) also contribute to the nationwide declines in fertility.

Taiwan continues to face a downward trend in fertility, and it is expected that the population will reach the stage of "zero growth" soon and turn into "negative growth" quickly. This means a decrease in young population and increase in aging population which will lead to tremendous social problems, such as the shortage of labor force, high dependency ratio, and rising healthcare expenditures. Two possible and interesting follow up questions are how the rapidly declining fertility changes the structure of ob/gyn market and the social value of newborns, especially women's attitude toward delivery modes.

2.4 National Health Insurance in Taiwan

In March 1995, Taiwan implemented a new NHI program that provides health insurance coverage to the entire population. Prior to NHI, the availability of health insurance was quite limited. Nearly half of the population was uninsured, and those not covered were mostly children, the elderly over sixty-five, and housewives. There was virtually no private health insurance coverage available prior to NHI (Peabody et al., 1995; Chou et al., 2001). Further, the reminder of the population received insurance through Labor Insurance for employees in the private sector, Government Employee Insurance for workers in the public sector, and Farmer Insurance for farmers.

The Bureau of National Health Insurance (BNHI) was established in January 1995, and two months later universal health insurance was inaugurated. After the NHI become effective, the administrations for the medical care benefits began to be operated by the BNHI. The BNHI then became the only health insurance provider, incorporating three important features: compulsory universal coverage, uniform comprehensive benefits, and financing through payment of a premium (via payroll deduction) with a heavy governmental subsidy. In addition, with a generous benefit package and low cost sharing, the insurance rate jumped to 92% at the end of 1995, and has stayed over 97% since 1997 (Lien et al., 2005).

Following the introduction of the NHI program, the BNHI became the only provider of health care insurance in Taiwan, with the contracted medical care institutions being mainly paid on a fee-for-service basis. However, some specific illnesses or medical services are reimbursed on a prospective payment system according to a patient's principal discharge diagnosis, or under principal operative procedures as defined by the International Classification of Diseases, Ninth Revision, Clinical Modification (ICD-9-CM).

Case payment diagnoses are reimbursed at fixed rates regardless of clinical severity, supplemented by a cost-based increment for outliers (Xirasagar and Lin, 2004). This payment method is designed to increase health care providers' cost consciousness. Reimbursement for complicated cases is based on a FFS scheme, but the total percentage of fee-for-service cases per provider cannot exceed a ceiling set by the BNHI (Tsai et al., 2003). The case payment policy also regulates the minimum requirement for medical services to ensure consistent quality of services. The minimum requirement recommends a treatment protocol for case payment patients, with the stipulation that hospitals have to perform all of the required services to be fully reimbursed (Chou et al., 2002).

Since health care providers in Taiwan are paid under the payment scheme set by BNHI in accordance with a schedule of fixed fees, it is difficult for hospitals to engage in price competition under such a highly price-regulated system. However, non-price competition could be increased after the implementation of NHI. For instance, small hospitals or clinics may merge to have better facilities and economic of scale to attract more patients and to get higher reimbursement rates. This also partly explained why the total number of hospitals/clinics decreased substantially after NHI.

2.5 General Background on Cesarean Delivery in Taiwan

After the inauguration of NHI, vaginal delivery and c-section (including CDMR) were both paid under PPS since March and September 1995 respectively, but CDMR is only reimbursed at the cost of vaginal delivery. According to NIH, CDMR is defined as a c-section for a singleton pregnancy, on maternal request, at term, in the absence of any medical or obstetrical indications for cesarean delivery. However, the magnitude of CDMR is hard to be confidently estimated given the available evidence and data in the world because currently CDMR is neither a well-recognized clinical entity nor an accurately reported indication for diagnostic coding or reimbursement. The knowledge base rests chiefly on indirect evidence from proxies possessing unique and significant limitations (Visewanathan, Visco, Hartman, Wechter, Gartlehner, Wu, Palmieri, Funk, Lux, Swinson, and Lohr, 2006). Fortunately, Taiwan has a national database that codes for CDMR separately, and makes it feasible to conduct the empirical analysis in this study.

In addition, the prospective reimbursement of singleton deliveries with pre-determined price by BNHI could make providers engage in non-price competition based on efficiency and quality to retain market. The permitted length of stay in the hospital is three days for a vaginal delivery and six days for a c-section, while one additional day being allowed if a labor induction is performed. According to Chou et al. (2002), under PPS, an adjustment for outliers is allowed, with the approved percentages of outlier cases to the total c-section cases, by hospital accreditation status, being between 5 percent and 15 percent in any month. To ensure consistent quality of services, the case payment policy also regulates the minimum requirement for medical services. The minimum requirement sets a treatment protocol for case payment patients, with the stipulation that hospitals have to perform all of the required services in order to be fully reimbursed. Under NHI, the indications for c-sections include antepartum hemorrhage, placenta previa, abruptio placentae, malpresentation, fetal distress, multiple pregnancies, cervical incompetence, dystocia, previous cesarean delivery, and macrosomia. If a woman does not have any of these conditions and decides to undergo an elective cesarean delivery (i.e., CDMR), then the BNHI will only reimburse the amount of the vaginal delivery, and the woman has to pay for the reimbursement difference between the vaginal and cesarean delivery to the provider.

Lin and Xirasagar (2004) provided a review of the cesarean rate in Taiwan and a comparison to other countries. They showed that since 1996 the overall c-section rate in Taiwan has ranged between 32% and 34%, which is lower than Chile and Brazil (40% and 36%, respectively). However, compared to the OECD (Organization for Economic Co-operation and Development) countries, such as the United Kindgom (21.4%), United States (24.4%), Italy (22.4%), and Sweden (11.9%), Taiwan's rate is higher than most of them. The Taiwanese rate is also much higher than the World Health Organization (WHO)'s recommended ceiling of 15%. WHO's suggestion of the overall c-section rate of 15% is based on the expected number of women who will face life-threatening complications during labor and delivery. This recommendation, however, is controversial due to the heterogeneity in society, culture, medical development and health care systems.

Moreover, Taiwanese physicians are either employed by a hospital or their own clinics, and clinics are permitted to have up to 9 beds (as well as basic inpatient and operating facilities), so ob/gyns can provide vaginal deliveries as well as c-sections in clinics. Using cross-sectional data from NHI in Taiwan, Lin and Xirasagar (2004) also concluded that institutional characteristics played an important role in determining the use of c-sections. For example, ob/gyn clinics providing the lowest level of obstetric care have higher rate of c-section compared with hospitals, which have obstetricians on staff and have better infrastructure to deal with neonatal problems. Moreover, the higher likelihood of undergoing a c-section at clinics is also attributed to physicians' time pressures. Ob/gyn clinics in Taiwan are mostly run by solo practitioners working, on average, 9.36 hours a day, 6.2 days a week. Solo ob/gyns are more vulnerable to overwork, often having to wait out unpredictable hours of labor. A scheduled delivery is a potential time-management solution, especially if comorbidities require close obstetric monitoring during labor.

In another study by Xirasagar, Lin, and Liu (2006), they used data from the 2000 to 2002 NHIRD to study the effect of group practice versus solo practice, and the group practice, the size of physician practice, on physicians' propensity of performing c-sections. They found that solo practices have 7% excess cesarean cases relative to large group practices, and most of those cases were with obstetrically less salient complications and the patients without any complications. Another report by NIH (2006) also emphasized that the rate of CDMR in Taiwan increased from 2 percent (of all women without a clinical indication for c-sections) in 1997 to 3.5 percent in 2001, with higher increase in women 35 an older (respectively, 3.6 % increased to

6.6%).

Nevertheless, the cross-sectional nature of their data limits the scope of the conclusions about causality. Longitudinal studies would enable tracking of physicians through their stints in solo practice, moving into group practice, and vice versa. Their study also generates another interesting research question: ob/gyn clinics may have different income-recovery strategies from hospitals when facing negative income shock due to fertility decline. Therefore, further analysis may consider classifying data into different categories of accreditation status and test the research hypotheses within each category.

Finally, an important fact to note about the ob/gyn market in Taiwan is that ob/gyns are either directly employed by hospitals and therefore receive salaries directly from their employers, or themselves are owners of private ob/gyn clinic. For ob/gyns employed by hospitals, there are usually two elements to their salaries: the normal contracted annual salary, and an additional payment based on the volume of services provided (e.g., the number of patients treated, the severity of cases, and so on) (Chou et al., 2002), so they are also provided with the incentive to supply excessive or more expensive care to their patients, especially as patients are not placed under any financial constraints under the NHI regime.

2.6 The Use of Inpatient Tocolysis

Several studies have reported that antenatal hospitalization with pregnancy-related diagnosis represents a significant health and economic burden for women of reproductive age (Hass, Berman, Goldberg, Lee, and Cook, 1996; Nicholson, Frick, and Powe, 2000; Bacak, Callaghan, Dietz, and Crouse, 2005). One of the most common reasons for antenatal hospitalizations is symptoms due to preterm labor (PTL). Tocolytic therapy refers to the use of pharmacologic agents to inhibit uterine contractions in preterm labor. The purpose is to prevent delivery before the completion of 37 weeks of gestation age and thus reduce the perinatal morbidity and mortality associated with preterm labor.

However, meta-analysis indicated that no studies to date have shown a reduction in perinatal mortality or the incidence of preterm birth with either acute or long-term tocolytic therapy. Goldberg (2002) stated that, for women with preterm labor, the use of tocolysis was frequently unnecessary, often ineffective, and occasionally harmful. Two recent studies further revealed that inpatient tocolysis led to poorer pregnancy and infant outcomes, while outpatient management improved these outcomes at lower costs (Ambrose et al., 2004; Coleman et al., 2005). An interesting fact to note in Taiwan is that the use of inpatient tocolysis is not parallel to the decreasing number of newborns. Why are there these two distinct trends? This give rise to the following question: dose the provider induce unnecessary inpatient tocolysis to recoup the income loss due to the dramatically declining number of births?

Another theoretical justification for exploring the relationship between fertility and tocolytic hospitalization is the “medical arm race” (MAR) hypothesis. As noted by Kessler and McClellan (2000), health insurance is the most important source that attribute to the differences between hospital markets and stylized markets, because health insurance dampens patients’ sensitivity to cost and price differences among hospitals. Under NHI, patients’ insensitivity to price may lead health care providers to engage in a “medical arm race” and compete through the provisions of more facilities (e.g., MRI), and another possible outcome from MAR is the over—supply of medically unnecessary services. Moreover, a “medical arm race” could lead to increased adverse patient outcomes because the provision of medically unnecessary service may fail to take advantage of scale and learning effects (Robinson and Luft, 1987; Shortell and Hughes, 1988). More detailed discussions can be found in a recent study by Chou, Liu, and

Hammitt (2004) which provides a complete review of Taiwan's hospital market after NHI. Moreover, Lien et al. (2006) and Chou et al. (2002) also showed that after the implementation of NHI, hospitals tend to attract more patients by providing the latest technology, excessive care, or lavish amenities. The relevant question in this study is, with the dramatic change in number of newborns, would ob/gyns provide more inpatient tocolysis which is a decision probably in the hand of them?

A crucial concern regarding the spillover over effects of the shrinking fertility is that inducement could happen in other services besides inpatient tocolysis. The number of c-sections and tocolytic hospitalizations may increase partially, but not enough to fully offset the income losses. So why focus on inpatient tocolysis? To my knowledge, inpatient services in the ob/gyn specialty under NHI can be divided into the following categories: obstetric delivery, tocolysis, abortion with complicated diagnosis, ectopic pregnancy, laparoscopy, procedure for malignancy, and procedure for non-malignancy. Among these services, tocolysis is more related to the circumstances with the rapidly dropping fertility (e.g., older marriage and childbearing age, and increasing utilization of artificial reproductive technology services), and provides the most direct test for the spillover effect of the declining fertility as well. Particularity, inpatient tocolysis is paid by a FFS payment scheme, which may promote an excessive use of services.

Outpatient services and services not covered by NHI (e.g., treatment for infertility) could offer other opportunities for providers to generate more revenue. For example, ob/gyns may perform an increasing array of other services that are traditionally under other specialties (known as "cross-specialty") when their incomes have been depressed. However, under the regulation of BNHI, ob/gyns are not allowed to perform inpatient or outpatient procedures in other specialties. Ob/gyns may prescribe drugs for common diseases (e.g., common cold), but the reimbursement on prescription is very low. In this study I am unable to investigate these alternatives due to the availability of data.

2.7 Contributions of This Study

This study builds and improves upon the existing literature on the correlation between the fertility, the use of c-sections and physician inducement in a number of ways. First of all, although some researchers have studied the economic determinants of cesarean delivery in the U.S., there is a distinct lack of related studies in other developed or developing countries where various progressive health care reforms are currently under way. This study contributes to the scant literature in this area by providing empirical evidence on the choice of obstetric deliveries as a result of dramatically declining fertility in Taiwan, using more recent data and wider range of variables.

Second, most current research has relied on regional samples, samples from selected hospitals or patient subpopulations, or samples lacking the required clinical information. This study has ensured access to the details of virtually all singleton delivery in the country because NHI covers almost the entire population, and the use of such a nationally representative dataset with comprehensive clinical information across all providers and patients will alleviate the potential selection bias. Moreover, the large sample size (of roughly 320,000 to 210,000 births a year) which would also provide greater statistical power, and hence a greater likelihood of yielding much more reliable analysis.

Third, information about beneficiary's employment status is typically unavailable in most insurance claims data. By matching the IDs in hospital discharge files and medical personnel files of NHIRD, this study can conduct a population-based research to compare the propensity of undergoing c-section of medically informed individuals versus other uninformed women. This method has better controls for the unobserved common factors affecting choices of delivery mode, and it is also more sophisticated and innovative than those empirical specifications employed in previous studies.

Fourth, the policy importance of this study is clear. Increased concern for rising c-section rates has led to the passage of legislation to reform reimbursement policy in many developed and developing countries, e.g., reducing the fee differential between c-section and vaginal delivery. The effects of such policy depend on the strength of provider financial incentives for c-section. In order to devise effective strategies for more rational policies of c-section, a better understanding of factors influencing the choice of delivery mode is essential. Results from this study can provide direct evidence to the debate: whether lowering reimbursement will lower the c-section rates.

Fifth, CDMR is not readily identifiable in any existing studies or U.S. national database, either currently or historically. Further, the existing literature has no consensus as to what extent the increasing use of c-section can be attributed to CDMR. Taiwan has a national database that codes for c-sections performed at maternal request, and this dataset thus presents a unique opportunity to separately identify the determinants of c-section and CDMR. This advantage also solves the ambiguity in prior findings: are the high c-section rates from ob/gyn's financial pressures under rapidly declining fertility rate, or the lower and lower fertility makes women request c-section to have their "high-premium babies"?

Sixth, although the overall c-section rate is relatively high and stable in Taiwan, there are big geographic variations in c-section rates and different trends of fertility declines across areas. With the use of difference-in-differences approach and panel data, these variations can be used to identify the effect of declining fertility rate on the use of c-section, conditional on patients' professional background and presumed access to health information.

Seventh, the analysis of spillover effects on tocolytic hospitalization will yield better understanding of provider's inducement behavior as suggested by McGuire (2000). Moreover, with rich NHIRD data on hospital, clinic and ob/gyn characteristics, this study can further test whether the inducement effects differ by various institutional factors and physician characteristics.

Finally and most importantly, the single-payer system is regarded as an effective tool to identify fraudulent claims and overcharges because better information can be used to build more complete provider and patient profiles (Lien et al., 2006). Lin et al. (2004) also pointed out, the universal health insurance and the single-payer system in Taiwan offers a favorable research setting, which is relatively free from the methodological encumbrances of fragmented health care market settings driven by a dynamic mosaic of constantly shifting payers, payment types, purchasers, and insured client base. Therefore, this study could improve significantly upon the methodology of earlier reports.

In summary, this study will add to the limited literature on this topic, and provide guidance to formulate effective policies to steer the health system toward appropriate obstetric care policies that are consistent with the clinical profile of cases.

Chapter 3: DATA AND MEASUREMENT

3.1 Data Sources

The primary data source in this study was obtained from Taiwan's National Health Insurance Research Database (NHIRD) regulated by the National Health Research Institute (NHRI), consisting of comprehensive longitudinal utilization and enrollment history of all NHI beneficiaries in Taiwan. This study combined the following NHRI datasets spanning from 1996 to 2004: registry for contracted medical facilities, registry for medical personnel, registry for contracted beds, registry for beneficiaries, registry for board-certified specialists, hospital discharge file, and registry for catastrophic illness patients. Because the NHI covers almost the entire population, this study essentially has information on every singleton delivery in Taiwan. According to NHRI data manuals, an enrollee loses his coverage in one of the following conditions: (1) died, (2) sentenced or jailed, (3) disappeared for over six months, (4) served in the army, (5) exceed the permitted stay or working permits; the last condition applies only to foreigners (Lien et al., 2004).

Moreover, each discharge record contains three scrambled but unique IDs: Hospital ID, Provider ID, and patient ID. Theses IDs can be used to link information of patients, providers and hospitals from other sources. In order to protect privacy and assure confidentiality, all unique personal identifiers were encrypted by the Bureau of National Health Insurance (BNHI) and any information which is potential to identify the study subject was deleted before releasing to the researchers. The confidentiality assurances were addressed by abiding by the data regulations of the BNHI. Because the risk of identifying individuals from the data released to the researchers is essentially zero, and IRB determined that this study does not constitute human subjects research as defined under federal regulations, this study does not require IRB approval.

Data in general fertility rate and population size are obtained from the Taiwan-Fuchien Demographic Fact Book, 1996-2004. These data are merged with the insurance claims data by the area codes.

3.2 Study Population

This study will first identify the singleton deliveries in Taiwan between 1996 and 2004 from the NHI hospital discharge data. To make the results from this study comparable to research from other countries, this study adopted the following exclusion criteria: women above 50 and below 15 years of age, attending ob/gyn's age below 25 and above 75, women with foreign nationality, and women whose deliveries involved more than one child. There are several reasons to apply those exclusion criteria. First of all, following Chou et al.'s (2006) research, women with foreign nationality were excluded because most of theses women are from mainland China (especially rural areas), Vietnam, and Indonesia, and they may have different and unobserved characteristics in choosing delivery mode, e.g., social, cultural milieu and associated beliefs. In addition, the c-section rates in those areas are much lower than in Taiwan. There are a total of 60,418 foreign women excluded from the study population.

Second, the exclusion restriction on age will make this study more comparable to prior research, because pregnancies in women under fifteen and over fifty years old are atypical and people rarely qualify as ob/gyns before the age of twenty-five and after seventy-five. This study excluded 159,179 observations below 15 or above 50 years of age, and 7,911 observations with attending ob/gyn's age below 25 and above 75.

Third, women with multiple pregnancies might have different obstetric considerations as to mode of delivery compared with women have singleton gestations (Lin, Sheen, Tang, and Kao, 2004). In this study, multiple pregnancies are identified by ICD-9-CM codes 651.0 to 651.93, and 26,671 cases of multiple pregnancies were excluded.

This study will use the complete case analysis (i.e., drop observations with missing values) to deal with the missing data problem. This is the most common approach and the advantage is that the results will be unbiased with missing completely at random data. However, if the data are just missing at random, estimates may be biased if the missingness depends on the dependent variable. The NHIRD is of good quality, and roughly 1% to 2% of the total observations are missing. Finally, this study has a total of 2,203,010 singleton deliveries in Taiwan between 1996 and 2004.

3.3 Measurements

3.3.1 Dependent variable

This study defined the outcome of delivery mode in accordance with the NHI diagnosis-related groups (DRG) codes in NHI hospital discharge file. Delivery modes are categorized as vaginal delivery (DRG = 0373A), c-section (DRG = 0371A), and c-section on maternal request (DRG = 0373B). In case there are some complicated c-section and vaginal delivery reimbursed on fee-for-service basis, this study also identified singleton deliveries by procedure codes and type of reimbursement from the hospital discharge file. In the hospital discharge file of NHIRD, procedure codes can be obtained from the variable called "ICD_OP_CODE" in the hospital discharge file. The code 72 or 73 represents c-section, while the code 740, 731, 742 or 744 represents vaginal delivery. In addition, in the hospital discharge file there is a variable called "GAVE_KIND" which can also be used to identify the mode of singleton deliveries. The code of 6 represents c-section, while the code of 7 represents vaginal delivery.

This study will first followed Lin et al.'s research (2006) to combine c-section and CDMR into one category. They argued that an ob/gyn may code a CDMR as a clinically indicated c-section to accommodate the mother's preference, and to help the patient avoid the 50% cost-share out-of-pocket that is required by BNHI for CDMR. Further, it is possible that some clinics, especially solo clinics, may be more inclined to upcode a CDMR to clinically indicated c-section. Thus, CDMR itself could be affected by provider preferences, and combining c-section and CDMR cases is a feasible way to avoid these sources of bias.

However, Lin et al.'s argument could be a little weak because many reports have shown that the rising trend of CDMR could be mainly attributed to psychosocial factors, such as to avoid painful labor (Nerum, Halvorsen, Sorlie, and Oian, 2006), which are quite different from the determinants of medically necessary c-section. The existence of increasing CDMR should not be ignored, and estimating the effects of declining fertility on c-section and CDMR separately will make the magnitude of inducement more precise as I stated in Chapter 1. Moreover, given the fact that the magnitude of CDMR cannot be validly estimated in the U.S. and internationally, the valuable information of CDMR in NHIRD should not be thrown off the bat. Robustness check (specifications with/without combination of CDMR) will be performed to confirm my findings, and I will have more detailed discussion on the robustness check in Chapters 4 and 5.

3.3.2 Identifying markets and measuring fertility rates

One of the key questions in this study is to proxy the income shock due to shrinking fertility in ob/gyn markets, and it is important to note that no single measure of a hospital's market is ideal for all research questions (Baker, 2001). According to Chou et al. (2002), there are three commonly adopted approaches to defining markets for the purpose of measuring market concentration, and the most straightforward one is the simple ad hoc method of definition involving the use of political or census divisions such as counties, Metropolitan Statistical Areas (MSA) (Joskow, 1980), Health Service Areas (HSA) and urbanized areas. This study defined the geographic markets in Taiwan based upon the health care service regions reported by the Department of Health in Taiwan. There are totally twenty-one health care service regions (For a complete list of healthcare service regions in Taiwan, please refer to http://www.tjcha.org.tw/news/news05.asp).

The fertility rate is calculated as the ratio of live births to the female population of child-bearing age, also known as the general fertility rate, for each subregion. Formally,

General Fertility Rate = [Number of Resident Live Births / (Female Population (aged 15-49))] x 1000

The general fertility rate is an age/sex-specific birth rate in which births to women less than 15 or more than 49 years are included, while the population for those ages is not. Hence, this study potentially improved previous estimations by taking the demographic composition into consideration. Moreover, the general fertility rate can be considered as the most direct proxy to the income pressure (Gruber et al., 1996), and it is surely exogenous because ob/gyn may affect where and how children are born, however, it is implausible to think that they can substantially affect the number of childbirth (Dranove and Wehner, 1993).

The fertility rate itself may not be a perfect measure of the effect of the financial pressure. As Gruber et al. (1996) pointed out, "if fertility decrease were increasing the financial pressure on ob/gyns, why should they continued to enter this field as such a rapid rate?" Indeed, the dynamic of ob/gyns market entry or exit could contradict the use of fertility as a proxy for the income pressure. If the rapidly declining fertility decreases medical students' willingness to choose ob/gyn specialty and leads more ob/gyns to exit the market such that the ratio of births to practicing ob/gyns remains constant, then ob/gyns' revenue from deliveries may not be affected.

To check this fact, I provide descriptive statistics of the effect of declining fertility on ob/gyns' revenue in section 3.4. Moreover, to control for both change in fertility and change of ob/gyn density in the area, I also try another empirical specification where the main explanatory variable is the number of ob/gyns per 100 births. Gaynor (1994) and McGuire (2000) explain that identification of the effect of financial pressure solely by ob/gyn density may cause bias and inconsistency in estimations because physician's decision to start a practice depends on market conditions. Furthermore, if there are unmeasured demand factors that influence both provider density and provider behavior, then the elasticities between them are potentially biased toward to zero. To solve this problem, I use the lag of the number of ob/gyns per 100 births to replace the number of ob/gyns per 100 births as an alternative specification. The lag of the number of ob/gyns should be highly correlated with the number of ob/gyns, but is unlikely to be correlated with unmeasured demand factors. Hence, the endogeneity issue should not be problematic in explaining the results.

3.3.3 Identifying the health information gap

The most important research question in this study is to compare the likelihood of choosing c-section delivery between medically-informed individuals versus other women under rapidly declining fertility, the identification of the health information gap is of critical importance in empirical specifications. The primary data are also from NHIRD, but BNHI only release the related data of female relatives of physicians from 2000 to 2003 to NHIRD (see also Chou et al., 2006).

Because this study first aims to compare the choice of delivery mode between female physicians and female relatives of physicians versus other women, the identification numbers listed on the hospital discharge files of pregnant women were matched against the medical personnel registry, to identify all pregnant women who had “physician” as their recorded occupation. Next, a woman living in the same household as a physician was considered the physician’s relative, regardless of her exact relationship with that physician. For this, I used the NHI hospital discharge files, the NHI Medical Personnel Registry and the Household Registry from 2000-2003. A household was defined as a person or group of people registered in the same dwelling, which made it possible to link different members of any household. Finally, those women who are not physicians or not living in the same household as a physician were defined as other women.

The second way to identify the health information gap in this study is to use socioeconomic status as a proxy of education level. Hence, the propensity of delivery mode choice of two subgroups of women (high socioeconomic versus low socioeconomic) will be compared. There will be more detailed description of the classification of high socioeconomic status women and low socioeconomic women in 3.3.6..

3.3.4 The use of inpatient tocolysis

To identify the use of inpatient tocolysis, this study first excluded early pregnancy loss and induced abortion from the hospital discharge file of NHRID. This study then follows a recent study by Coleman et al. (2005) to define inpatient tocolytic hospitalization with the following ICD-9-CM codes: 644.00 (early or threatened labor, unspecified as to episode of care or not applicable), 644.03 (early or threatened labor, antepartum condition or complication), 644.10

(other threatened labor, unspecified as to episode of care or not applicable), and 644.13 (other threatened labor, antepartum condition or complication) from the antenatal hospitalizations. In the hospital discharge file of NHRID, each patient record has one principal diagnosis, as listed in the ICD-9-CM, and up to four secondary diagnoses. This study first identified tocolytic hospitalization from the primary and secondary diagnosis, and then the data were aggregated to the hospital and ob/gyn level by year. Because these codes ended with either "0" or "3", they are all undelivered hospitalization and will not include any expenditures of delivery. To verify this, I also compared tocolysic hospitalization cases with singleton delivery cases defined in section 3.3.1., and there are no overlaps between them.

Following Coleman et al.'s (2005) approach, this study further excluded women contraindicated for tocolysis according to the current standard of care and women noted to have additional medical conditions that could have been treated with medications misclassified with tocolysis, because these conditions require immediate c-section (e.g., eclampsia, excessive maternal bleeding, and placenta previa) or termination of pregnancy (e.g., congenital abnormalities, incompetent cervix, and premature rupture of membranes), usually depending on patient's severity and gestation age. The exclusion criteria included: hypertension/eclampsia/pre-eclampsia (ICD-9-CM 642), excessive maternal bleeding/abrupted placenta/placenta previa (ICD-9-CM 762.0, 762.1, 762.2), premature rupture of membrances/incompetent cervix (ICD-9-CM 761), fetal distress (ICD-9-CM 656.3, 663.0, 768.3 and 768.4), maternal infection/chorioamnionities (ICD-9-CM 762.7), and congenital abnormalities (ICD-9-CM 740-759). Note that women with congenital abnormalities were excluded because these conditions may place them in a unique category with respect to both indications for tocolysis and neonatal outcomes (Coleman et al., 2005). The selection criteria for inpatient tocolysis are also listed on Table 2.

3.3.5 Clinical indicators

The conceptual basis for the empirical analysis of c-section rates is that ob/gyns' decisions are influenced by clinical indicators and other non-clinical factors such as institutional factors, physician characteristics, insurance status and socioeconomic characteristics of mother such as income and age (Dubay et al., 1999).

Following the study by Chou et al. (2006), this study will gather information about medical risk factors and complications associated with c-sections from the NHI inpatient discharge files. Since patient parity is not available in this data set as in most claims data, this study adopted a standard classification and decision rule of mutually exclusive diagnosis developed ICD-9-CM is used to code these complications. They include previous c-section (ICD-9-CM 654.2), fetal distress (ICD-9-CM 656.3, 663.0, 768.3, and 768.4), dystocia (ICD-9-CM 652.0, 652.3-652.4, 652.6-652.9, 653, 659.0, 659.1, 660, 661.0-661.2, 661.4, 661.9, and 662), breech (ICD-9-CM 652.2 and 669.6), and other complications (ICD-9-CM 430-434, 641, 642, 647.6, 648.0, 648.8, 654.6, 654.7, 655.0, 656.1, 656.5, 658.1, 658.4, and 670-676). Those complications are also listed on Table 3.

Finally, this study also used the proportion of patients with a major disease/injury card to control for patient health status when investigating the spillover effects on hospitals, clinics, and ob/gyns. The registry for catastrophic illness patients in NHRID was used to identify individuals with major diseases or injuries (for the complete list of major disease/injury, see http://www.nhi.gov.tw/webdata/webdata.asp?menu=1&menu_id=6&webdata_id=396). In Taiwan, patients with specific major diseases or injury can apply for a "major disease/injury card." Based on the Injury Severity Index, the NHI major disease list includes 30 major disease or injury types such as cancer, end-stage renal disease, chronic psychotic disorder, cirrhosis of the liver, acquired immunodeficiency syndrome, and schizophrenia.

3.3.6 Nonclinical indicators

Nonclinical factors include patient age, aborigine, socioeconomic status, and institutional factors. This study obtained information related to the age, ethnic status, and socioeconomic status of mothers from the NHI enrollment files, while information associated with institutional factors are from the registry for contracted medical facilities and registry for medical personnel. Ethnic groups were categorized as aboriginal or non-aboriginal. A limitation of the NHIRD is that the information on ethnic groups is only available from 2000-2003 data.

Socioeconomic status was defined as mother's own monthly insurable wage if she is the insured or the monthly insurable wage of the insured if she is a dependent. The NHI program is financed by wage-based premiums on people with clearly-defined monthly wage and fixed premiums on people without clearly-defined monthly wage. As with the ethnic status, the complete information of mother's own insurable wage is only available from 2000-2003 data. Next, mothers with clearly defined monthly insurable wage were assigned to one of the three socioeconomic categories.

High socioeconomic status women were defined as those women with monthly insurable wage greater than or equal to NT$60,000 (≧US$1,920). Middle socioeconomic status women were defined as those women with monthly insurable wage between NT$10,000 and NT$59,999 (US$ 320-US$ 1,919). Low socioeconomic status women were defined as those women with monthly insurable wage less than NT$10,000 (<US$ 320). Mothers without clearly-defined monthly insurable wage were mostly vulnerable people such as farmers, fishermen and low-income people, and so they were assigned to the low socioeconomic status group as those women with insurable wage as those women with monthly insurable wage less than NT$10,000

(<US$ 320). Due to the limitation of the data, the occupation status of the husband cannot be clearly identified in this study.

Institutional factors include hospital ownership (public hospital, voluntary nonprofit hospital, and private hospital), teaching status (teaching or non-teaching institution), accreditation status (medical center, regional hospital, district hospital, and ob/gyn clinics). Under NHI, hospitals/clinics are classified to four levels (based on bed capacity and clinical capacity): medical centers (minimum 500 beds), regional hospitals (minimum 250 beds), district hospitals (minimum 20 beds), and clinics (fewer than ten beds, all privately owned). All medical centers and regional hospitals are teaching hospitals, as are some distinct hospitals (Lin et al., 2004). For clinics, they are all non-teaching institution. Other control variables include the number of attending ob/gyns in each hospital/clinic, ob/gyn gender ratio, mean of ob/gyn age, mean of attending ob/gyn's years in ob/gyn specialty, and bed size to measure the size of delivery services because the size of delivery services could also affect c-section rates (McKenzie and Stephenson, 1993). Physician characteristics include attending ob/gyn's age, years in ob/gyn specialty, and gender. To avoid multicollinearity, this study does not include attending ob/gyn's age and years in ob/gyn specialty in empirical specifications because ob/gyn's age is a surrogate for duration of practice experience (Lin et al., 2004).

3.4 Sample Statistics

This study first got rid of all observations with missing values and identified a total of 2,203,010 singleton deliveries in Taiwan between 1996 and 2004 from the NHI inpatient discharge data after each exclusion criteria. Table 4 outlines the use of vaginal deliveries, c-sections, and CDMR from 1996 to 2004. Overall, the nation-level c-section rate slightly increased over the sample years (from 30.87% in 1996 to 31.92% in 2004). Notably, the rate of CDMR was 0.80% in 1996 and peaked at 2.38% in 2003.

Table 5 shows two sources of identifying variation in this study: geographic variations of fertility and c-section rates over time. But more importantly, the key criterion is that the differences of the probability of undergoing c-section between the treatment group (medically-informed individuals) and comparison group (less medically-informed individuals) do vary across areas and over time, and it is yet to be calculated in Chapter 5.

Due to the availability of information on ethic group and monthly insurable wage, the final analytic sample where individual patient is the unit of observation will only contain data from 2000 to 2003. Testing of the spillover effect on tocolysis where the unit of observation is individual ob/gyn or hospital and clinics will contain data from 1996 to 2004.

Table 6 displays the descriptive statistics of the analytical file. Approximately 33% of births are by c-section over the sample year. The average age to give birth was 28.24, and the average age of undergoing c-section was older than that of vaginal delivery as generally expected. The most striking difference between the c-section and vaginal delivery columns is having a previous c-section. Among all vaginal delivery cases, only 0.67% had previous c-section, but 43.27% of all c-section cases had a previous c-section.

Table 2. Selection criteria for inpatient tocolysis

Variable	ICD-9-CM	Note
Early pregnancy loss hospitalization	630-634 and 637-639	
Antenatal hospitalization	640-676 with fifth digit of "3"	Nondelivery Non pregnancy loss hospitalization
Inpatient Tocolysis	Define from antenatal hospitalization	With PTL-related diagnosis: 644.00, 644.03, 644.10, 644.13 But exclude 642, 762.0, 762.1, 762.2, 761, 656.3, 768.3, 768.4 762.7, 740 to 759

Notes: All cases have to exclude 635, 636 (induced abortion)

Table 3. List of complications for c-section

Complications	ICD-9-CM
Previous cesarean section	654.2
Fetal distress	656.3, 663.0, 768.3, and 768.4
Dystocia	652.0, 652.3-652.4, 652.6-652.9, 653, 659.0, 659.1, 660, 661.0-661.2, 661.4, 661.9, and 662
Breech	652.2 and 669.6
Other complications	430-434, 641, 642, 647.6, 648.0, 648.8, 654.6, 654.7, 655.0, 656.1, 656.5, 658.1, 658.4, and 670-676

Table 4. Summary statistics of the use of vaginal deliveries, c-sections, and CDMR, 1996-2004

Year	Number of singleton deliveries	Number of vaginal deliveries (%)	Number of c-sections (%)	Number of CDMR (%)
1996	300,045	207,410 (69.13%)	90,223 (30.07%)	2412 (0.80%)
1997	298,284	203,809 (68.33%)	90,450 (30.32%)	4025 (1.35%)
1998	240,820	160,889 (66.81%)	75,665 (31.42%)	4256 (1.77%)
1999	249,950	167,615 (67.06%)	77,929 (31.18%)	4406 (1.76%)
2000	267,201	178,657 (66.86%)	82,956 (31.04%)	5588 (2.09%)
2001	221,974	147,739 (66.56%)	68,482 (30.85%)	5753 (2.59%)
2002	211,089	139,420 (66.05%)	60,109 (28.47%)	5780 (2.74%)
2003	204,046	137,082 (67.18%)	62,109 (30.44%)	4855 (2.38%)
2004	209,601	142,699 (68.08%)	63,251 (30.18%)	3651 (1.74%)
Total	2,203,010	1,485,330 (67.42%)	676,954 (30.72%)	40,726 (1.85%)

Notes: compared to the numbers in Table 1, the sample in Table 4 is the study population for this research, which means multiple pregnancies, women with foreign nationality, women with attending ob/gyn's age below 25 and above 75, and women aged below 15 as well as above 50 were all dropped.

Table 5. Sources of identifying variations

County/City	Decreases in general fertility rate (GFR) from 1996 to 2004			Changes in C-section rate from 1996 to 2004		
	GFR in 1996	GFR in 2004	Change	C-section rate in 1996	C-section rate in 2004	Change
Taipei City	41.09	28.81	-12.08	32.78	33.31	+0.53
Kaohsiung City	41.15	26.83	-13.32	39.80	38.05	-1.75
Taipei County	43.65	28.44	-15,21	34.33	32.16	-2.17
Ilan County	56.35	34.49	-21.69	25.35	29.79	+4.44
Taoyuan County	55.48	36.22	-19.48	34.76	36.15	+1.39
Hsinchu County	69.15	47.14	-22.01	30.89	28.69	-2.20
Miaoli County	61.18	40.28	-22.28	34.19	29.80	-5.29
Taichung County	54.91	34.98	-19.93	34.49	32.72	-1.77
Changhua County	56.36	38.93	-17.43	27.80	26.30	-1.50
Nantou County	56.96	37.08	-19.61	30.12	26.46	-3.66
Yunlin County	61.02	41.41	-19.83	32.65	29.63	-3.02
Chiayi County	62.12	42.30	-18.62	35.71	28.80	-6.37
Tainan County	50.86	32.14	-18.42	32.00	31.10	-0.90
Hualien County	56.14	37.75	-18.39	27.85	27.46	-0.39
Penghu County	54.35	34.88	-19.47	28.48	38.99	14.51
Kaohsiung County	51.06	32.66	-18.40	33.35	33.40	+0.05
Pingtung County	55.06	33.60	-21.46	28.72	34.80	+6.08
Taitung County	56.14	37.75	-18.39	26.18	37.90	+11.72
Hsinchu City	53.01	42.06	-10.95	33.42	27.83	-5.59
Chiayi City	44.98	29.46	-15.52	33.95	38.36	+4.41
Taichung City	48.19	29.00	-19.19	30.95	31.07	+0.12
Tainan City	40.53	27.66	-12.87	34.93	34.74	-0.19
Kinmen County	52.03	43.63	-8.4	18.56	31.13	+12.77

Notes: There are two sources of identification in this study. The first one is the declines in fertility across areas over time (obtained from the Taiwan-Fuchien Demographic Fact Book). The second one is the c-section rates across areas and over time (obtained from Department of Health, Taiwan). The shaded rows mean that the c-section rates increased from 1996 to 2004.

Chapter 4: EMPIRICAL SPECIFICATIONS

4.1 Identification Strategy

The theoretical model used for motivating the empirical estimation is the McGuire and Pauly's (1991) model of physician response to fee changes with multiple payers. Rather than assuming the existence or non-existence of target income, McGuire and Pauly's model is a general model of physician behavior with a subjective inducement costs that encompass both benchmark of profit maximization and target income (Yip, 1998). Their model shows that the strength of the income effect is the critical factor in determining the magnitude of inducement, suggesting that empirical research should focus on estimating the income effect.

This study will start with the basic specification of the relationship between the fertility rate and the use of c-sections. However, regarding the inducement studies, one of the most important empirical questions is the issue associated with obtaining unbiased (or consistent) estimates of the reduced-form effects of exogenous changes in various fertility rates that can affect providers' financial incentives as well as their inducement behavior.

To obtain a more accurate estimation of the inducement effect, the empirical strategy of this study is to compare the treatment group (less medically-informed individuals) and the comparison group (medically-informed individuals) in the probability of undergoing a c-section. The study design exploits the fact that the fertility rate change varies in different market areas. The difference in probability of undergoing c-section between the treatment and comparison groups in localities with smaller declines in fertility accounts for any systematic structural change, while the difference in localities with larger declines in fertility reflects both the systematic structural change and the impact of the inducement. Therefore, the difference-in-differences (DD) estimates will identify the pure inducement effect of the shrinking fertility on ob/gyn's financial incentives. Moreover, another convenient feature of the regression format of DD is that it allows us to easily control for any time-varying factors which we are worried may be correlated with the exogenous shock (i.e., fertility change).

Next, this study examined the spillover effect of the dramatic change in fertility on provider practice level. Using the same hospital discharge file from NHRID, the units of observation will be both individual hospital and ob/gyn to account for the characteristics of Taiwan's ob/gyn market.

4.2 Research Hypotheses

There are four testable research hypotheses in this study:

Hypothesis 1: An exogenous decrease in fertility will lead to an increase in the likelihood of undergoing c-section.

Hypothesis 2: Being less-medically-informed will have a greater likelihood of undergoing c-section under the exogenous decrease in fertility.

Hypothesis 3: The dramatic change in fertility caused a negative income shock to providers (hospitals and clinics).

Hypothesis 4: The negative income shock to providers will lead them to recoup the reductions in their practice revenue by supplying more tocolytic hospitalizations.

4.3 Probit Model

In the empirical specification with respect to the first two research hypotheses, the dependent variable is dichotomous: vaginal delivery and c-section, and vaginal delivery will serve as the reference group. To test the first hypothesis, this study initially runs a probit regression of the form:

$$Pr(Y_{ighrt} = 1) = \Phi[\alpha + \gamma_1 \, ln(Fertility_{rt}) + \beta_1 X_{ighrt} + \beta_2 Z_{ghrt} + \beta_3 H_{hrt} + \delta_r + \varsigma_t + \mu_i + \varepsilon_{ighrt}] \quad (1)$$

where *Y* is the dichotomous choice of delivery mode (0 if vaginal delivery, 1 if c-section), Φ is the standard normal cumulative distribution, α is the constant term, *i* indexes individual patient, *g* indexes ob/gyn, *h* indexes hospital, *r* indexes subregion, *t* indexes time, β and γ are the coefficients on the explanatory variables. $ln(Fertility_{rt})$ is the log of region's general fertility rate in year *t*. A full set of regional and year dummies are also included to control for the regional fixed effects (δ_r) and time fixed effects (ς_t), respectively. The regional fixed effects (δ_r) measures unobserved regional preferences for care or hospital selection. *X* is a vector of observable patients' characteristics, including their age, aboriginal status, having previous c-section, complications for c-section (i.e., fetal distress, dystocia, breech, and other complications), and insurable wage. Further, *Z* is a vector of observable ob/gyn characteristics, including ob/gyn's age and ob/gyn's gender. The variable years in ob/gyn specialty is not included in the regression because it is highly collinear with ob/gyn's age, and ob/gyn's age can be a surrogate for duration of practice experience (Lin et al., 2004). *H* is a vector of observable hospital characteristics, including teaching status, accreditation status, ownership, bed size, and number of board-certified ob/gyns. ε_{ighrt} is the random error assumed to be independent of all other error terms. Under the first research hypothesis, γ_1 in (1) is expected to be negative. In this specification, the effect of financial pressure is solely identified from changes in fertility which is surely exogenous.

However, the use of the log of region/year general fertility rate may not be a perfect measure of the income shock for ob/gyns due to declining fertility, because ob/gyns are not immobile. In other words, ob/gyns may respond to the falling fertility by changing their location or even exit the market. Further, medical students' entry into obstetrics and gynecology may be decreasing if fertility decreases were increasing the financial pressure to ob/gyns (Gruber et al., 1996). Therefore, the number of ob/gyns per 100 of birth could provide an appropriate measure of the negative income shock for ob/gyns. To take the dynamic of ob /gyn market into account, an alternative specification is:

$$Pr(Y_{ighrt} = 1) = \Phi[\alpha + \gamma_1 \, ln(OBBIRTH_{rt}) + \beta_1 X_{ighrt} + \beta_2 Z_{ghrt} + \beta_3 H_{hrt} + \delta_r + \varsigma_t + \mu_i + \varepsilon_{ighrt}] \quad (2)$$

where $ln(OBBIRTH_{rt})$ is the log of the number of ob/gyns per 100 of birth. γ_1 in (2) is expected to be positive. i.e., c-sections are more likely to be performed where either the supply of ob/gyns is rising or the number of births is falling. Note that $ln(OBBIRTH_{rt})$ could be endogenous because it explicitly includes the number of ob/gyns in each region, and ob/gyns' decision to start a practice depends on market conditions. If ob/gyns migrate to regions where there is excess demand for ob/gyn services, then the number of ob/gyns per 100 of birth and the use of c-sections would be positively correlated. Nevertheless, it is difficult to find a valid instrument variable for $ln(OBBIRTH_{rt})$ in the data. Thus, this study tried two different types of specifications in equations (1) and (2) to test for the first hypothesis.

For the second research hypothesis, the pure magnitude of inducement can be identified using the availability of health information along with the geographic variation in fertility rates, and this strategy is a difference-in-differences (DD) approach. More formally, the samples of comparison and treatment groups can be pooled and estimated by the following reduced form the probit equations, and the probability that patient *i* undergoing c-section with ob/gyn *g* in hospital *h* in region *r* at time *t* is then given by:

$$Pr(Y_{ighrt} = 1) = \Phi\lfloor \alpha + \gamma_1 \, ln(Fertility_{rt}) + \gamma_2 Info_{ighrt} + \gamma_{12} \, ln(Fertility_{rt}) \times Info_{ighrt} + \beta_1 X_{ighrt}$$

$$+\beta_2 Z_{ghrt} + \beta_3 H_{hrt} + \delta_r + \varsigma_t + \mu_i + \varepsilon_{ighrt} \rfloor \quad (3)$$

and

$$Pr(Y_{ighrt} = 1) = \Phi\lfloor \alpha + \gamma_1 \, ln(OBBIRTH_{rt}) + \gamma_2 Info_{ighrt} + \gamma_{12} \, ln(OBBIRTH_{rt}) \times Info_{ighrt} + \beta_1 X_{ighrt}$$

$$+\beta_2 Z_{ghrt} + \beta_3 H_{hrt} + \delta_r + \varsigma_t + \mu_i + \varepsilon_{ighrt} \rfloor \quad (4)$$

where $Info_{ighrt}$ is an indication of being medically informed individuals (female physicians and female relatives of physicians, or high socioeconomic status women). In (3) and (4), the main variables of interest are the interaction terms $ln(Fertility_{rt}) \times Info_{ighrt}$ and $ln(OBBIRTH_{rt}) \times Info_{ighrt}$. In the probit model, the interaction effect cannot be evaluated simply by looking at the sign and significance of the coefficient on the interaction term, and the interaction effect requires computing the cross derivative or the cross difference (Ai and Norton, 2003; Norton, Wang, and Ai, 2004). With one continuous variable $ln(Fertility_{rt})$ or $ln(OBBIRTH_{rt})$ and one dummy variable ($Info_{ighrt}$) interacted in the above probit equation, the interaction effect is the discrete difference (with respect to $Info_{ighrt}$) of the single derivative (with respect to $ln(Fertility_{rt})$ or $ln(OBBIRTH_{rt})$. Formally,

$$\frac{\Delta \dfrac{\partial E\left[Y_{ighrt} \mid ln(Fertility_{rt}), Info_{ighrt}, W\right]}{\partial\, ln(Fertility_{rt})}}{\Delta Info_{ighrt}} = (\gamma_1 + \gamma_{12})\phi((\gamma_1 + \gamma_{12})ln(Fertility_{rt}) + \gamma_2 + W\beta) - \gamma_1\phi(\gamma_1 LFertility_{rt} + W\beta)$$

and

$$\frac{\Delta \dfrac{\partial E\left[Y_{ighrt} \mid ln(OBBIRTH_{rt}), Info_{ighrt}, W\right]}{\partial\, ln(OBBIRTH_{rt})}}{\Delta Info_{ighrt}} = (\gamma_1 + \gamma_{12})\phi((\gamma_1 + \gamma_{12})ln(OBBIRTH_{rt}) + \gamma_2 + W\beta) - \gamma_1\phi(\gamma_1 \ln(OBBIRTH_{rt}) + W\beta)$$

where $E\left[Y_{ighrt} \mid ln(Fertility_{rt}), Info_{ighrt}, W\right]$ and $E\left[Y_{ighrt} \mid ln(OBBIRTH_{rt}), Info_{ighrt}, W\right]$ are the conditional means of the dichotomous dependent variable Y_{ighrt}, ϕ is the probability density function of the standard normal distribution, and the vector *W* represents all exogenous right hand side variables. Clearly, the magnitude of the marginal effect is conditional on the value of the independent variables. The marginal effect of the interaction term thus captures the rapidly declining impact on the inducement of those who are less medically-informed individuals affected by the ob/gyns' inducement, relative to medically-informed individuals who are less likely to be affected by the ob/gyns' inducement behavior. If the inducement hypothesis holds, the interaction effect is expected to be positive and significant. Unfortunately, the marginal effect of the interaction term is very difficult to compute in STATA package due to the extremely large sample size in this study. I thus calculate the marginal effect of the interaction term using the average of the probabilities method. The method is to calculate the probability for each observation four times with changing the character of interest (i.e., log of general fertility rate and information status), and then recalculate the marginal effect interaction term.

As mentioned in 4.1, this study used a DD method to get the pure effect of inducement. Theoretically, we know that the level of inducement could be higher for poorly informed patients, and we can expect that women in areas with lower fertility rate are more likely to be induced to get a c-section than those in areas with higher fertility rate. So conceptually, by comparing the likelihood of undergoing a c-section on medically-informed women versus less-medically informed women with respect to variations in decreasing fertility across different regions in Taiwan, the magnitude of inducement can be more accurately estimated.

Empirically, I took double difference from the probit or MNL models to get the marginal effects of the interaction terms. More specifically, the marginal effect of the interaction term can be expressed as:

Inducement effect = $\left\lfloor \hat{P}_{gfr2003,NI} - \hat{P}_{gfr2000,NI} \right\rfloor - \left\lfloor \hat{P}_{gfr2003,I} - \hat{P}_{gfr2000,I} \right\rfloor$

In the above equation the difference term p-hat with average general fertility rate in 2003 of informed patients minus p-hat with average general fertility rate in 2000 of informed patients captures the unobserved common factors, and the difference-in-differences estimate can give the pure effect of demand inducement.

Thus, the inducement effect=

$$\begin{bmatrix} (Pr(LGFR = 3.5835189, I = 0)) \\ -(Pr(LGFR = 3.871201, I = 0)) \end{bmatrix} - \begin{bmatrix} (Pr(LGFR = 3.5835189, I = 1)) \\ -(Pr(LGFR = 3.871201, I = 1)) \end{bmatrix}$$

or

$$\begin{bmatrix} (Pr(LOBBIRTH = -0.3206919, I = 0)) \\ -(Pr(LOBBIRTH = -0.5523823, I = 0)) \end{bmatrix} - \begin{bmatrix} (Pr(LOBBIRTH = -0.3206919, I = 1)) \\ -(Pr(LOBBIRTH = -0.5523823, I = 1)) \end{bmatrix}$$

Because the general fertility rate is a continuous variable, I used the log of general fertility rate in 2000 (3.871201) and 2003 (3.5835189) and the log of number of ob/gyns per 100 of birth in 2000 (-0.5523823) and 2003 (-0.3206919) to plug in the above equation. Then the inducement effect can be obtained by taking double differences of the predicted probabilities.

Finally, all above equations will be estimated with the Huber-White robust standard errors, in order to control for the heteroskedasticity in nonlinear models. Also, all equations will be estimated with the cluster option in STATA to adjust standard errors for intragroup correlation, and the cluster identifier is the highest level units of the model (i.e., hospital).

4.4 Multinomial Logit Model

Now consider the existence of CDMR in the original dataset, the discrete outcome variable can take one of three mutually-exclusive alternatives (c-section, CDMR, and vaginal delivery). Let *W* (more specifically, W_{ighrtj}) denote a set of explanatory variables

$\left[ln\left(Fertility_{rt}\right),\ X_{ighrt},\ Z_{ghrt},\ H_{hrt},\ \delta_r,\ \varsigma_t\ \right]$ or $\left[ln\left(OBBIRTH_{rt}\right), X_{ighrt},\ Z_{ghrt},\ H_{hrt},\ \delta_r,\ \varsigma_t\right]$ in

equations (1) and (2), or

$\left[ln\left(Fertility_{rt}\right), Info_{ighrt}, ln\left(Fertility_{rt}\right)\times Info_{ighrt}, X_{ighrt},\ Z_{ghrt}, H_{hrt}, \delta_r, \varsigma_t\right]$ or

$\left[ln\left(OBBIRTH_{rt\,rt}\right), Info_{ighrt}, ln\left(OBBIRTH_{rt}\right)\times Info_{ighrt}, X_{ighrt},\ Z_{ghrt}, H_{hrt}, \delta_r, \varsigma_t\right]$ in (3) and (4) when

considering the role of health information gap. Thus the vector *W* includes regional-specific, provider-specific, and patient-specific attributes. Furthermore, I follow the majority of papers in the literature to assume that all women maximize a parameterized indirect utility function (V_{ighrtj}). This is necessary to ease the econometric estimation. The indirect utility V_{ighrtj} that woman *i* with her choice of delivery alternative *j* is composed of systematic component $W'_{ighrtj}\,\beta_j$ and random disturbance term ε_{ighrtj} :

$$V_{ighrtj} = W'_{ighrtj}\, \beta_j + \varepsilon_{ighrtj}$$

As is well-known in the discrete choice literature, the observed choice is determined by the difference in utility, not with the levels of utility per se. In other words, for identification purposes the parameters of one alternative must be normalized. Following the convention, I choose alternative 3 (vaginal delivery). Hence, subtract from the utility of each alternative *j* the utility associated with alternative 3:

$$v_{igher1} = V_{ighrt1} - V_{ighrt3} = W'\left(\beta_1 - \beta_3\right) + \varepsilon_{ighrt1} - \varepsilon_{igher3}$$

$$v_{ighrt2} = V_{ighrt2} - V_{ighrt3} = W'\left(\beta_2 - \beta_3\right) + \varepsilon_{ighrt2} - \varepsilon_{igher3}$$

For simplicity, rewrite theses two equations as:

$$v_{i1} = W'\,\overline{\beta}_1 + \overline{\varepsilon}_{ighrt1}$$

$$v_{i2} = W'\,\overline{\beta}_2 + \overline{\varepsilon}_{ighrt2}$$

The MNL specification results if one assumes the disturbance terms ε_{ighrtj} are identically and independently disturbed (IID) with Type I extreme value density functions. The probability that a woman *i* chooses alternative $j\left(j \in \{1,2\}\right)$ with ob/gyn *g* in hospital *h* in region *r* at time *t* is then given by:

$$p_{ighrtj} = Pr\left(Y_{ighrt} = j\right) = \frac{exp(W'_{ighrtj}\,\overline{\beta}_j\,)}{\sum_{l=1}^{2} exp(W'_{ighrtl}\,\overline{\beta}_j\,)} \tag{5}$$

where Y indicates the discrete choice of delivery mode (1 if c-section, and 2 if CDMR). The main advantage of this specification is its ease of computation. Indeed, the probability of choosing alternative j is a closed-form equation of the sample data Interpretation for the MNL model is relative to the reference or base category group, and that is why MNL has been used so frequently in the empirical literature (Bolduc, Lacroix, and Muller, 1996). Here the coefficients on vaginal delivery were normalized to zero. Finally, the marginal effect of the interaction term $ln(Fertility_{rt}) \times Info_{ighrt}$ or $ln(OBBIRTH_{rt}) \times Info_{ighrt}$ can also be obtained by the average probabilities method as described in the end of 4.3, and the standard error as well as the confidence interval of the marginal effect of can be computed by bootstrapping.

The main drawback of the MNL model is that it imposes the property of independence from irrelevant alternatives (IIA): the discrimination among the three alternatives reduces to a series of pairwise comparisons that are unaffected by the characteristics of alternatives other than the pair under consideration (Cameron and Trivedi, 2005). This property is a consequence of the implied assumption of no correlation between the error terms. The IIA property can be tested by a Hausman test.

In the Hausman test for the IIA property, the null hypothesis is that IIA assumption is true, which means the model can be reestimated with fewer categories, and then the estimates of the remaining parameters should not change. The model with more categories will be more efficient if the IIA assumption is true, but will be inconsistent if it is false.

The Hausman statistics is:

$$H = \left(\hat{\theta}_{FEW} - \hat{\theta}_{MORE}\right)' \left(Var\left[\hat{\theta}_{FEW}\right] - Var\left[\hat{\theta}_{MORE}\right]\right)^{-1} \left(\hat{\theta}_{FEW} - \hat{\theta}_{MORE}\right)$$

where $\hat{\theta}_{FEW}$ is the vector of estimated coefficients from the MNL with fewer categories, and $\hat{\theta}_{MORE}$ is the vector of estimated coefficients from the MNL with more categories. The Hausman statistic has a χ^2 distribution, and the number of degrees of freedom is the rank of $\left(Var\left[\hat{\theta}_{FEW}\right] - Var\left[\hat{\theta}_{MORE}\right]\right)$.

Likewise, all above equations will be estimated with the Huber-White robust standard errors, in order to control for the heteroskedasticity in nonlinear models. Also, all equations will be estimated with the cluster option in STATA to adjust standard errors for intragroup correlation, and the cluster identifier is the highest level units of the model (i.e., hospital).

4.5 Discrete Factor Model

In spite that many variables of patients, ob/gyns, and hospitals are added in the estimation, the results may still be subject to biases and inconsistency if the unobserved errors (μ_i) are not carefully controlled. For example, women's personal preferences on delivery mode and health status may be difficult to be fully represented by a vector of patients' observed characteristics.

To have better control for the unobservable individual heterogeneity (μ_i), this study will specify a nonparametric discrete framework where μ_i is assumed to follow a discrete distribution with Q points of support. This method provides a nonparametric, discrete approximation to the true distribution of unobservable characteristics (Mays, 1999). According to Mroz and Guilkey (1996), Monte Carlo studies have showed that the discrete factor methods performed nearly as well as parametric maximum likelihood methods when the distributional assumptions correspond to the true distribution of unobservable characteristics. When the distributional assumptions are incorrect, these studies indicate that the discrete factor method produces estimates that are less biased than those of parametric methods. The distribution of μ_i is defined as:

$$Pr(\mu_i = \mu_q) = \pi_c(q), \text{ for } q = 1,2,...,Q.$$

The contribution to the likelihood function for an individual patient *i* with ob/gyn *g* in hospital *h* in region *r* at time *t*, conditional on the unobserved heterogeneity is:

$$L_{ighrt}(\mu_i) = [\Phi(\bullet)]^{Y_{ighrt}}[1-\Phi(\bullet)]^{1-Y_{ighrt}}$$

where $\Phi(\bullet) = Pr(Y_{ighrt} = 1)$ as defined in (2).

The contribution to the likelihood function for an individual patient *i* with ob/gyn *g* in hospital *h* in region *r* at time *t*, unconditional on unobserved individual heterogeneity, is then given by integrating over the possible values of the discrete factors

$$L_{ighrt} = \sum_{q=1}^{Q} \pi_c(q) \cdot L_{ighrt}(\mu_i)$$

The full likelihood function can be expressed as the product of *N* unconditional individual-specific likelihoods:

$$L = \prod_{i=i}^{N} L_{ighrt}$$

This likelihood function is maximized with respect to the parameters defined in (1) and (2), along with the additional parameters associated with the discrete distributions that are used to approximate the distribution of unobserved individual heterogeneity. These additional parameters are the locations of the points of support in each distribution, and the probabilities associated with each point. Initially, I use four points of support for the discrete distribution (*Q*=2). Then I use the likelihood ratio tests to determine whether more points should be added to improve the model as suggested by Mroz (1997).

To test for the unobserved heterogeneity, this study uses likelihood ratio test to compare the model with and without controlling for unobserved heterogeneity and the null hypothesis is that all μ_i are jointly equal to 0. In this test, the discrete factor model will serve as the unrestricted mode, where the probit or the mlutinomial model without controlling for unobserved heterogeneity will serve as the restricted model. The likelihood ratio test statistic can be expressed as:

$$LR = -2\left[ln\,L\left(\tilde{\theta}_r\right) - ln\,L\left(\hat{\theta}_u\right)\right] = 2\left[ln\,L\left(\hat{\theta}_u\right) - ln\,L\left(\tilde{\theta}_r\right)\right]$$

where $\hat{\theta}_u$ is the unrestricted MLE, and $\tilde{\theta}_r$ is the restricted MLE. Because this study estimates the discrete factor model with two points of support, the LR test is asymptotically distributed with χ^2 with two degrees of freedom. The critical value is 5.99.

4.6 Estimations of the Spillover Effect

To test the spillover effect of declining fertility on the tocolytic hospitalization, this study also performed an analysis on practice level where the unit of observation is the individual physician and hospital. McGuire and Pauly's research (1991) showed that income effect is the key determinant of a physician's volume response to a fee cut (Yip, 1998). To the extent that other inpatient services could provide another avenue for recouping income losses, a strong and negative income effect will lead to an increase in the volume of other services after a dramatically declining fertility.

Empirically, this study constructs a "*BITE*" variable to measure the effect on the number of newborns change as it changes the income of the hospital and ob/gyn's practice (i.e., the financial pressure of each hospital and ob/gyn). In Taiwan, because the prices are exogenously determined by the BNHI, the substitution effect in Yip's paper can be ignored. Thus,

$$BITE_{ht} = \frac{P_t^1 Q_{ht}^1 + P_t^2 Q_{ht}^2}{\sum_{i=1}^{N} P_t^n Q_h^n}$$

and

$$BITE_{gt} = \frac{P_t^1 Q_{gt}^1 + P_t^2 Q_{gt}^2}{\sum_{i=1}^{N} P_t^n Q_g^n}$$

where *h* indexes individual hospital and *g* indexes individual ob/gyn, respectively. P_t^1 is the price for c-section at year *t*, and P_t^2 is the price for vaginal delivery at year *t*. Both P_t^1 and P_t^2 are set by BNHI, and it means they are exogenously determined. Q^1 is the volume for c-section and Q^2 is the volume for vaginal delivery. Q_t^n is the total quantity of each inpatient services that the hospital and ob/gyn performed each year, and $\sum_{i=1}^{N} P_t^n Q_t^n$ represents mean of total inpatient revenue for each provider from 1996 to 2004. According to Yip (1998), if *BITE* is normalized by total practice volume, then it could understate or overstate total practice revenue and lead to attenuation bias. Hence, in this study *BITE* is normalized by the average of total inpatient revenue to allow for wide variations of the different services that the provider supplies. Moreover, *BITE* also indicates that a hospital or an ob/gyn with a larger share of obstetric deliveries experiences a larger income effect than one with a smaller share of obstetric deliveries.

The estimation of the spillover effect can be described as the following:

$$Q_{hrt}^3 = \alpha + \beta_1 BITE_{ht} + \beta_2 X_{hrt} + \beta_3 Z_{ghrt} + \beta_4 H_{hrt} + \delta_r + \varsigma_t + \eta_h + \varepsilon_{hrt} \qquad (6)$$

and

$$Q^3_{grt} = \alpha + \beta_1 BITE_{gt} + \beta_2 X_{hrt} + \beta_3 Z_{ghrt} + \beta_3 H_{hrt} + \delta_r + \varsigma_t + \lambda_g + \varepsilon_{hrt} \qquad (7)$$

where Q^3 is the quantity of inpatient tocolysis provided, η_h and λ_g are the unobserved hospital's and ob/gyn's specific errors respectively. *X* is a vector of observed, time-varying patient characteristics, including the proportion of patients with major disease card and the average of patients' age. Z and *H* are vectors of observable, time-varying ob/gyn and hospital characteristics, respectively. ε_{hrt} and ε_{grt} are white noise errors assumed to be independent of all other error terms.

Following Yip's methods, this study then took the first difference to eliminate the unobserved provider and locality fixed effects that may be correlated with *BITE*. $\Delta BITE$ is the first difference version of *BITE* and it is equal to the weighted sum of newborn number changes faced by the provider, with the weights equal to the shares of the obstetric deliveries in the provider's total inpatient practice revenue. Theoretically or empirically, there is no justification for preferring the base-, terminal-, or mean-year revenue as weights. As pointed out by Yip (1998), "if the errors are identically and independently distributed, using the base-year volumes as weights leads to negative bias, while using the terminal-year volumes as weights leads to positive bias. However, the mean-year volumes will result in unbiased estimates." Differencing equation (2) and (3) between periods $t-1$ and t yields the following:

$$\Delta Q^3_{hrt} = \beta_1 \Delta BITE_{ht} + \beta_2 \Delta X_{hrt} + \beta_3 \Delta Z_{ghrt} + \beta_4 \Delta H_{hrt} + \Delta\varsigma_t + \Delta\varepsilon_{hrt} \qquad (8)$$

and

$$\Delta Q^3_{grt} = \beta_1 \Delta BITE_{gt} + \beta_2 \Delta X_{hrt} + \beta_3 \Delta Z_{ghrt} + \beta_4 \Delta H_{hrt} + \Delta\varsigma_t + \Delta\varepsilon_{hrt} \qquad (9)$$

where $\Delta BITE = \dfrac{\Delta P_t^1 Q_{ht}^1 + \Delta P_t^2 Q_{ht}^2}{\sum_{i=1}^{N} P_t^n Q_h^n}$

and

$$\Delta BITE = \frac{\Delta P_t^1 Q_{gt}^1 + \Delta P_t^2 Q_{gt}^2}{\sum_{i=1}^{N} P_t^n Q_g^n}$$

Note that by taking first difference of equation (2) and (3), the unobserved hospital's, ob/gyn's, and locality fixed effects (η_h, λ_g, and δ_r) are all eliminated. $\Delta\varsigma_t$ then captures any trend and technology effects on the tocolytic hospitalization. If the spillover effect is significant in determining the volume increase in response to the declining births, the β_1's are expected be negative and significant in both equations (4) and (5).

4.7 Robustness Check

This study will do the following robustness checks of the above specifications. For equations (1) and (2), I include either hospital fixed effects or ob/gyn fixed effects, which is likely to be correlated with women's unobserved individual health conditions. For example, hospitals with distinctive services (such as neonatal technology) will tend to be located in city centers or in densely populated sectors within which there exist substantial economies of scale. Thus, the more seriously ill, or riskier patients, tend to go to hospitals located within a metropolitan area (Chou et al., 2002). Consequently, hospital fixed effects or ob/gyn fixed effects are likely to be correlated with patients unobserved health characteristics. When hospital fixed effects or ob/gyn fixed effects are included in the model, regional fixed effects are all dropped out because most providers did not move in the short run. So the robustness checks for equation (1) and (2) can be expressed as follows:

$$Pr(Y_{ighrt} = 1) = \Phi[\alpha + \gamma_1 \, ln(Fertility_{rt}) + \beta_1 X_{ighrt} + \beta_2 Z_{ghrt} + \beta_3 H_{hrt} + \delta_r + \varsigma_t + \theta_h + \varepsilon_{ighrt}] \quad (10)$$

$$Pr(Y_{ighrt} = 1) = \Phi[\alpha + \gamma_1 \, ln(Fertility_{rt}) + \beta_1 X_{ighrt} + \beta_2 Z_{ghrt} + \beta_3 H_{hrt} + \delta_r + \varsigma_t + \theta_g + \varepsilon_{ighrt}] \quad (11)$$

$$Pr(Y_{ighrt} = 1) = \Phi[\alpha + \gamma_1 \, ln(OBBIRTH_{rt}) + \beta_1 X_{ighrt} + \beta_2 Z_{ghrt} + \beta_3 H_{hrt} + \delta_r + \varsigma_t + \theta_h + \varepsilon_{ighrt}] \quad (12)$$

$$Pr(Y_{ighrt} = 1) = \Phi[\alpha + \gamma_1 \, ln(OBBIRTH_{rt}) + \beta_1 X_{ighrt} + \beta_2 Z_{ghrt} + \beta_3 H_{hrt} + \delta_r + \varsigma_t + \theta_h + \varepsilon_{ighrt}] \quad (13)$$

where θ_g and θ_h refer to ob/gyn fixed effects and hospital fixed effects, respectively.

Chapter 5: EMPIRICAL RESULTS

5.1 Descriptive Statistics

5.1.1 Individual characteristics

Table 6 outlines a total of 854,820 singleton deliveries in Taiwan between 2000 and 2003 from the NHI inpatient discharge data after each exclusion criteria. Because the information about ethnic status and insurable wage are only available from 2000 to 2003 as described in previous chapter, these women are used in further analysis. Because this study aims to compare the c-section rates between female physicians, female relatives of physicians versus other women, to make two groups more comparable, I further excluded 9,406 women who are disabled or with major diseases or illnesses from the study population. This ends up with a final sample of 588 female physicians, 5,021 female relatives of physicians, and 849,211 other women. Table 7 presents the sample characteristics and c-section rates by physicians, relatives of physicians, and other women. Overall, 302,355 (35.4%) cases involved c-section delivery, and both physicians and physicians' relatives had lower crude c-section and CDMR rates than other women.

Next, this study also compares the c-section rates between high socioeconomic women versus low socioeconomic women from the 2000-2003 sample. Using insurable wage as a proxy of socioeconomic status, 9,343 high socioeconomic women and 139,565 low socioeconomic women were identified. The descriptive statistics of these two group are shown in Table 8. Overall, high socioeconomic status women had higher c-section and CDMR rates than other women, but these rates were not adjusted for any complications (e.g., age and clinical complications).

5.1.2 Distribution of ob/gyn characteristics

Table 9 describes the summary statistics of hospital and clinic characteristics from 1996 to 2004. It is clear from this table that the number of hospitals and clinics reduced substantially from 1996 to 2004. However, the average number of total beds rises from 135.99 in 1996 to 186.92 in 2004, showing that the hospital industry actually grows over time. The distribution of ownership and accreditation status did not vary too much over time, but the proportion of teaching hospitals increased a lot from 1996 to 2004 (from 7.81% to 22.97%).

Table 10 displays the summary statistics of ob/gyn characteristics from 1996 to 2004. The average age of ob/gyns and the average years in ob/gyn specialty both slightly increased over the years, and it is possible due to less and less young ob/gyns are willing to enter the market. For the gender distribution, the proportion of female ob/gyns also slightly increased over the years.

From 1996 to 2004, there were a total of 3,044 ob/gyns and 1,182 hospitals and clinics involved in this study. Tables 11 lists the number of attending ob/gyns and the average number of singleton delivery cases performed as well as the reimbursements received by them from 1996 to 2004. The number of ob/gyns decreased a little over the years. The average revenue from singleton deliveries of ob/gyns has been affected much more than that of hospitals and clinics, and it confirms that the declining fertility did cause negative income shock to ob/gyns. This also provides some evidence to support research hypothesis 3.

Table 12 presents the effect of declining fertility on hospitals/clinics' revenue. Table 12 further lists the average number of singleton delivery cases performed and revenue generated by those hospitals/clinics. Unlike Table 11, because the number of hospitals/clinics reduced substantially over time, the average annul revenue from singleton deliveries does not change a lot. However, it dose not mean that declining fertility did not cause negative income shock to hospital/clinics, but need more evidence to support research hypothesis 3.

Table 13 and 14 show summary statistics on the volumes (the dependent variable of interest) and revenues from inpatient tocolysis from 1996 to 2004. Both total volumes and revenues increased over time, and it could provide some empirical evidence to support the idea that ob/gyns induced more tocolytic hospitalizations to recoup their income loss due to dramatically declining fertility. Also note that the treatment intensity (measured by LOS and mean ob/gyn level revenue as well as mean hospital/clinic revenue) increased over time given the fact that fertility is lower and lower, these descriptive statistic provide some evidence to support the spillover effect on tocolytic hospitalization (research hypothesis 4).

5.2 Effects of Declining Fertility on the Use of C-section

5.2.1 Probit model

This section discusses the probit models which have a binary outcome: c-section and vaginal delivery. All probit regressions include regional fixed effects which take account the systematic differences in regional patient preferences being unobservable, and should mitigate the effects of endogeneity caused by unobserved regional preferences for the choice of delivery mode. A set of time dummies are also included to control for time fixed effects which are assumed to be “fixed” (the same) for all observations.

Table 15 presents the results from basic probit regressions for equation (1) to (3). In specification 1, there is a significant ($p<0.05$) negative relationship between the log of general fertility rate and the probability of undergoing c-section. In specification 2 where the log of number of ob/gyn per 100 births is the main explanatory variable, the probability of having c-section was significantly ($p<0.001$) increasing where the number of ob/gyn per 100 births was increasing. Both specification 1 and 2 are supportive of the traditional induced-demand view;

that is, the probability of undergoing c-section rates was rising when the number of ob/gyns was increasing and when the fertility rate was declining. However, the coefficient on the log of general fertility rate in specification 1 could be underestimated in the short term, because it ignores the adjustment in market dynamics.

As mentioned in previous chapter, the variable number of ob/gyn per 100 births could be endogenous because physician's decision to start a practice depends on market conditions. To further explore the problem of endogeneity of the main explanatory variable in specification 2, in specification 3, I used the lag of the number of ob/gyns in the main explanatory variable. The results are almost identical to specification 2 ($p<0.001$ for the log of number of ob/gyn per 100 births), although the coefficient of the main explanatory variable is a little lower then that in specification 2. It also indicated that the endogeneity of the log of the number of ob/gyn per 100 births may not be a serious concern.

In the probit model, the coefficients are not directly interpretable, but they can be translated to marginal effects. The magnitude of these marginal effects represents a percentage point change in the probability. So how large are these effects? The marginal effects can be obtained by using the following formula method for probit model:

$$\frac{\partial E[y|X]}{\partial X_i} = \hat{\beta}_i \phi(X\hat{\beta})$$

Using the above formula, one percent decrease in the general fertility rate led to 0.102 percentage points increase in the probability of having c-section, and one percent increase in ob/gyn per 100 births would increase in the probability of having c-section by roughly 0.064 percentage points, both are relatively small but significant ($p<0.05$ and $p<0.01$, respectively). The marginal effect from specification 3 is 0.011 (i.e., one percent increase in ob/gyn per 100 births is associated with 0.011 increase in the probability of having c-section) and is smaller compared to specification 2.

A possible explanation for the small magnitude of the marginal effect is that a c-section is fairly inexpensive relative to other “replacement” of medical technologies (Gruber et al., 1996), so when facing rapidly declining fertility rate, ob/gyns can provide more supply to other inpatient/outpatient procedures that are more lucrative than c-sections. Also note that the sign and significance of coefficients on the main explanatory variable are supportive of traditional inducement point of view, it does not necessarily mean there exists inducement because the maternal request is omitted.

For other explanatory variables in the probit regressions, as expected, the clinical categories “previous c-section” and clinical complications for c-section all have high likelihood of c-sections relative to vaginal deliveries. Older women were more likely to have c-sections, in line with clinical expectations. The results also showed that the medical centers and district hospitals have higher likelihood of undergoing c-sections, but the probability of having c-section in regional hospitals is lower (compared to clinics). Teaching institutions are more likely to have c-sections than non-teaching institutions, and the high incidence at teaching hospitals could be reflecting clinical care provision by inexperienced residents or could represent the sequelae of conservative clinical policies favoring vaginal delivery (Lin et al., 2004). Compared to public hospitals, private non-profit hospitals have lower propensity to perform c-sections, while proprietary hospitals/clinics have higher propensity to perform c-sections.

5.2.2 Robustness checks

This section reports the robustness checks for 5.2.1. The estimations for equations (10) to (13) are showed on Table 16. The sign and significance of the main explanatory variables remain unchanged from Table 15. Because a hospital’s or an ob/gyn’s characteristics are unlikely to change over time, the hospital or ob/gyn fixed effects essentially removes the explanatory power of many hospital related variables. Moreover, it is computationally demanding to include hospital or ob/gyn fixed effects in the empirical specifications Hence, the following specifications will only include a full set of regional and time dummies in the probt, MNL, or discrete factor models.

5.2.3 MNL model

To further investigate the effects of declining fertility on the choice mode, this study then estimated the effects of declining fertility on the use c-section and CDMR separately. In the MNL model, vaginal delivery was treated as the base outcome, and interpretation for the MNL model is relative to this base outcome.

Empirical results (see Table 17 and Table 18) shows that decline in the general fertility rate or increase in the number of ob/gyns per 100 of births did not lead to any significant change in the probability of having c-sections, but significantly increased the likelihood of undergoing CDMR ($p<0.05$ for log of general fertility rate and $p<0.001$ for log of number of ob/gyns per 100 of births, respectively) compared to vaginal delivery. The magnitude of the response to fertility change can be measured using the marginal effects averaged over individuals. The marginal effects of the main explanatory variables are not significantly different from zero for c-sections, -0.036 ($p<0.05$) for CDMR if the log of generally fertility is the main explanatory variable, and 0.037 ($p<0.01$) for CDMR if the log of ob/gyn per 100 births is the main explanatory variable. In other words, a one percent decrease in the general fertility rate is associated with 0.036 percentage points increase in the probability of having CDMR than vaginal delivery, and a one percent increase in ob/gyn per 100 births will lead to 0.037 percentage points increase in the probability of having CDMR than vaginal delivery.

5.2.4 Summary of results

To sum up, the rapidly decreasing fertility, either measured by the general fertility rate or ob/gyn per 100 births, would increase the likelihood of having c-sections, and the MNL models suggested that most of increases in c-sections are CDMR. As stated in previous chapter, given some alternative explanations, finding statistically significant effects in 5.2.1 and 5.2.2 does not necessarily mean there exists inducement, and vice versa. Next section will further examine the role of asymmetric information and the existence of demand inducement in the use of c-sections.

5.3 The Role of Information Gap and the Inducement Effects

This section presents the DD results from the probit model and MNL model respectively. In the probit model, c-section and CDMR are combined into one category, while in the MNL model they are treated separately. A DD estimate of the effect of the declining fertility on the choice of delivery mode as well as the pure effect of inducement can be constructed from these models by adding the interaction term "information × log of general fertility rate" or "information × log of ob/gyn per 100 births" in the empirical specification. The marginal effect of the interaction term (the inducement effect) can be obtained by taking double differences of the predicted probabilities.

5.3.1Probit model

Table 19 presents the effects of general fertility rate and the availability of the health information on the probability of undergoing c-sections. The first two columns in table 19 shows estimations from the probit model where the comparison group is female physicians and female relatives of physicians, and the treatment group is other women. The last two columns in table 19 shows estimations from the probit model where the comparison group is high socioeconomic status women, and the treatment group is low socioeconomic status women. The marginal effects of the interaction term from both estimations show that, on average, the declining fertility rate did not increase the use of c-sections conditional on patients' professional background and presumed better access to health information.

Table 20 presents the effects of the number of ob/gyn per 100 births and the availability of health information on the probability of undergoing c-sections. Again, results from Table 20 did not support the research hypothesis that being less-medically informed will have greater likelihood of undergoing c-sections under the exogenous decrease in fertility.

5.3.2 MNL model

Tables 21 to 24 present the empirical results from the MNL models with two definitions on health information gap. These findings show that the marginal effects on the interaction term "information $\times$ log of general fertility rate" and "information $\times$ log of ob/gyn per 100 births" are not statistically different from zero. Hence, although decline in fertility would increase the income pressure on ob/gyns, it did not lead them to substitute the higher reimbursed c-sections. Moreover, even a significantly negative correlation between fertility and use of CDMR has been confirmed in previous section, the effects did not vary across different availability of health information, on average.

The test for IIA property failed to work because the matrix $\left(Var\left[\hat{\theta}_{FEW}\right]-Var\left[\hat{\theta}_{MORE}\right]\right)$ is not positive definite. This is a limitation and weakness of the MNL model. Thus, the conditional probability may depend on other alternatives.

5.3.3 Summary of results

Findings from the probit and MNL models do not support the research hypothesis that being less-medically informed individuals will have a greater likelihood of undergoing c-sections under the exogenous decline in fertility. Furthermore, even the declining increase the probability of having CDMR, the effects did not vary across different availability of health information.

5.4 Discrete Factor Model

To have better control for the unobserved individual heterogeneity, this study also estimates equations (1) to (5) by the discrete factor model. This study estimates the probit and MNL models with two points of support because the log likelihood value has no improvements when estimating with more than two points of support.

5.4.1 Probit model with two points of support

Results from Table. 25 confirm the sign and significance from previous estimations (Table 15). Decline in general fertility rate will increase the likelihood of undergoing c-sections, and increase in the number of ob/gyn per 100 births has the same impact on the use of c-sections. Tables 28 and 29 further confirm the sign and significance from previous estimations (Tables 19 and 20). Note that the LR tests from Table. 25, 28, and 29 all reject the null hypothesis that all μ_i =0. Therefore, coefficients from the discrete factor model are conditional on the individual heterogeneity, and are not directly interpretable.

5.4.2 MNL model with two points of support

Table. 26 re-estimated Table. 17 and Table. 27 re-estimated Table 18. with two points of support for μ_i . Both tables confirm the sign and significance from previous estimations. Tables

30 to 33 re-estimated Tables 21 to 24 with two points of support for μ_i. Again, the sign and significance from previous estimations got confirmed, and the magnitudes of the coefficients are very close to each other. However, the LR tests from these tables all reject the null hypothesis that all μ_i =0, so the existence of individual heterogeneity still make the coefficients from these tables not directly interpretable.

5.4.3 Summary of results

The empirical results suggest that the inducement effect on c-sections is approximately zero. However, declining fertility will lead to more use of CDMR. There are two possible explanations. Women are more likely to have CDMR when fertility rate goes down because they believe that c-sections are safest for the baby. As Weaver, Statham and Richards (2007) pointed out, psychological issues and maternal perceptions of risk appear to be significant factors in many maternal requests, and maternal request is perceived by obstetricians to be a major factor in driving the c-section rate upward. Another explanation is the culture and social factors in Chinese society regarding the use of c-sections: avoiding fetal and maternal risks, exercising autonomy to make an independent choice, Chinese belief systems, and rejoicing and regretting. (Lee, Holroyd, and Ng, 2001). With the continued decreasing fertility, it is plausible that women prefer more CDMR to ensure a perfect birth outcome.

5.5 Test of the Spillover Effect on Inpatient Tocolysis

5.5.1 Estimations of spillover effect inpatient tocolysis

First of all, because this study constructs a "*BITE*" variable to measure the effect on the number of newborns change as it changes the income of the hospital and ob/gyn's practice, I provide a simple test to show the correlation between the decline in fertility and $\Delta BITE$. As expected, the correlation coefficient between general fertility rate change and $\Delta BITE$ is 0.457 (p<0.001) if individual ob/gyn is the unit of analysis, and is 0.429 (p<0.001) if individual hospital/clinic is the unit of analysis.

A further test of demand inducement hypothesis on inpatient tocolysis is presented on Table. 34. The first two columns are the estimations where the individual hospital or clinic is the unit of observation, and the next two columns are the estimations where the individual ob/gyn is the unit of observation. In Taiwan, most ob/gyns who treat patients in hospitals are employee of these organizations, and their salaries are usually proportional to the revenue they can generate. So it makes sense to get similar results using individual hospital/clinic or ob/gyn as the unit of observation. There are significantly ($p<0.05$) negative spillover of the income effects on tocolytic hospitalization. In other words, a provider with a larger share of singleton delivery income experiences a larger income effect than one with small share of singleton delivery income, and the income effect is significant in determining the volume increase in inpatient tocolysis in response to an exogenous fertility decline.

5.5.2 Comparison of Coefficients on $\Delta BITE$ with respect to different institutional factors

This study did not find a significant effect of the negative income shock on inpatient tocolysis at medical centers and ob/gyn clinics. The zero income effect in clinics is not a surprise, and the most plausible explanation is that most ob/gyn clinics do not have enough ob/gyns on staff and better infrastructure to deal with complicated maternal and neonatal problems. For medical centers, because the turn-over rate of inpatient tocolysis is much lower than other ob/gyn inpatient procedures, they may tend to refer patients who needs tocolystic hospitalization to regional or district hospitals, which often have more empty beds.

Furthermore, it has been discussed in previous literature that private providers may respond more aggressively than private non-profit or public providers to the financial incentives (Sloan, 2001). However, this study shows that public and private non-profit providers have considerably more negative income effect than private providers. There are several possible explanations. Most private providers are ob/gyn clinics in Taiwan, and they usually do not have staff and facilities to handle patients who need hospitalization with PTL problems. Besides, ob/gyn clinics may have other different strategy to recoup their income loss due to declining fertility, e.g., providing more outpatient services.

5.5.3 Summary of results

Although this study did not find a statistically significant inducement effect on the use of c-sections under the rapid declining fertility rate, some providers may recoup their income loss by supplying more tocolytic hospitalization. Essentially, from the idea that if a change in the physician's return from inducement (e.g., fertility goes down) stimulates a change in influence (more inpatient tocolysis supplied), this study still provides some evidence of physician-induced demand (PID).

Table 6. Summary statistics of patients by delivery modes, 2000-2003

Variables	All births	Vaginal delivery	C-section	C-section on maternal request
Main explanatory variables				
General fertility rate (S.D.)	41.78 (9.87)	42.07 (9.92)	41.37 (9.81)	39.55 (9.02)
Ob/gyn per 100 birth	0.67 (0.16)	0.67 (0.16)	0.67 (0.16)	0.69 (0.17)
Social-demographic variables				
Age (S.D.)	28.42 (4.55)	27.91 (4.39)	29.38 (4.65)	29.14 (4.84)
Female physicians (%)	588 (0.07%)	401 (0.07%)	176 (0.06%)	11 (0.05%)
Female relatives of physicians (%)	5021 (0.59%)	3,331 (0.60%)	1,586 (0.56%)	104 (0.51%)
Insurable wage (S.D.)	21834.95 (13701.35)	21799.48 (13563.81)	21856.91 (13831.14)	22493.2 (15473.73)
Aborigine (%)	23,818 (2.79%)	15,334 (2.78%)	8,186 (2.90%)	298 (1.46%)
Hospital characteristics				
Bed size (S.D.)	488.28 (750.64)	487.57 (746.99)	492.67 (759.89)	446.83 (718.61)
Ownership				
Public (%)	95,282 (11.15%)	60,162 (10.89%)	33,361 (11.83%)	1,758 (8.61%)
Private non-profit (%)	253,644 (29.67%)	165,581 (29.97%)	82,744 (29.35%)	5,320 (26.06%)
Proprietary (%)	505,894 (59.18%)	326,722 (59.14%)	165,837 (58.82%)	13,335 (65.33%)
Accreditation status				
Medical center (%)	144,436 (16.90%)	92,089 (16.67%)	48,862 (17.33%)	3,486 (17.08%)
Regional hospital (%)	210,313 (24.60%)	138,891 (25.14%)	67,468 (23.93%)	3,953 (19.37%)
District Hospital (%)	219,254 (25.65%)	141,526 (25.62%)	71,607 (25.40%)	6,121 (29.99%)
Clinic (%)	280,817 (32.85%)	179,959 (32.57%)	94,005 (33.34%)	6,853 (33.57%)
Teaching status				
Teaching (%)	442,354 (51.75%)	267,430 (48.41%)	136,002 (48.24%)	9,035 (44.26%)
Non-teaching (%)	412,466 (48.25%)	285,035 (51.59%)	145,940 (51.76%)	11,378 (55.74%)
Ob/gyn characteristics				
Gender (S.D.)	0.93 (0.24)	0.93 (0.25)	0.94 (0.25)	0.95 (0.22)
(0 if female; 1 if male)				
Ob/gyn age (S.D.)	39.49 (1.88)	39.47 (1.88)	39.52 (1.91)	39.53 (1.74)
Complications in c-section				
Fetal distress (%)	21,478 (2.51%)	2,127 (0.39%)	19,106 (6.78%)	245 (1.20%)
Dystocia (%)	150,644 (17.62%)	5,938 (1.07%)	142,443 (50.52%)	2,263 (11.09%)
Breech (%)	64,055 (7.49%)	825 (0.15%)	62,734 (22.25%)	496 (2.43%)
Others (%)	52,010 (6.08%)	12,806 (2.32%)	38,187 (13.54%)	1,017 (4.98%)
Previous c-section (%)	129,119 (15.10%)	2,512 (0.45%)	124,832 (44.28%)	1,775 (8.70%)
Obs.	854,820	552,465	281,942	20,413

Table 7. Summary statistics of patients by health information gap (defined by occupational status), 2000-2003

Variables	Female physicians	Female relatives of physicians	Other women
Dependent variables			
Vaginal delivery (%)	401 (68.20%)	3,331 (66.34%)	548,733 (64.62%)
C-section (%)	176 (29.93%)	1,586 (31.59%)	280,180 (32.99%)
C-section on maternal request (%)	11 (1.87%)	104 (2.07%)	20,298 (2.39%)
Main explanatory variables			
General fertility rate (S.D.)	38.46 (8.68)	39.78 (9.40)	41.80 (9.88)
Ob/gyn per 100 birth	0.76 (0.17)	0.73 (0.17)	0.67 (0.16)
Social-demographic variables			
Age (S.D.)	31.60 (3.18)	30.53 (3.82)	28.41 (4.55)
Insurable wage (S.D.)	53616.55 (22855.03)	33996.31 (18821.92)	21741.08 (13598.89)
Aborigine (%)	3 (0.51%)	39 (0.78%)	23,776 (2.80%)
Hospital characteristics			
Bed size (S.D.)	1621.33 (1017.08)	1058.62 (969.43)	484.13 (747.05)
Ownership			
Public (%)	243 (41.33%)	1,503 (29.93%)	93,536 (11.01%)
Private non-profit (%)	277 (47.11%)	2,130 (42.42%)	251,238 (29.58%)
Proprietary (%)	68 (11.56%)	1,388 (27.64%)	504,437 (59.40%)
Accreditation status			
Medical centers (%)	446 (75.85%)	2,438 (48.56%)	141,553 (16.67%)
Regional hospitals (%)	82 (13.95%)	1,296 (25.81%)	208,935 (24.60%)
District Hospitals (%)	34 (5.78%)	699 (13.92%)	218,521 (25.73%)
Clinics (%)	26 (4.42%)	588 (11.71%)	280,202 (33.00%)
Teaching status			
Teaching (%)	537 (91.33%)	3,962 (78.91%)	407,968 (48.04%)
Non-teaching (%)	51 (8.67%)	1,059 (21.09%)	441,243 (51.96%)
Ob/gyn characteristics			
Gender (S.D.) (0 if female; 1 if male)	0.003 (0.06)	0.93 (0.26)	0.94 (0.25)
Ob/gyn age (S.D.)	42.18 (3.23)	47.37 (10.64)	39.44 (1.59)
Complications in c-section			
Fetal distress (%)	16 (2.72%)	100 (1.99%)	21,362 (2.52%)
Dystocia (%)	98 (16.67%)	928 (18.48%)	149,618 (17.62%)
Breech (%)	46 (7.82%)	422 (8.40%)	63,587 (7.49%)
Others (%)	65 (11.05%)	358 (7.13%)	51,587 (6.07%)
Previous CD (%)	75 (12.76%)	681 (13.56%)	128,363 (15.12%)
Obs.	588	5,021	849,211

Table 8. Summary statistics of patients by health information gap (defined by insurable wage), 2000-2003

Variables	**High socioeconomic status women**	**Low socioeconomic status women**	**Other women**
Dependent variables			
Vaginal delivery (%)	5,635 (60.31%)	89,295 (63.98%)	457,536 (64.81%)
C-section (%)	3,282 (35.13%)	46,366 (33.22%)	232,294 (32.91%)
C-section on maternal request (%)	426 (4.56%)	3,904 (2.80%)	16,083 (2.28%)
Main explanatory variables			
General fertility rate (S.D.)	34.65 (5.45)	41.57 (9.70)	41.92 (9.92)
Ob/gyn per 100 birth	0.80 (0.18)	0.67 (0.16)	0.67 (0.16)
Social-demographic variables			
Age (S.D.)	32.78 (3.68)	27.11 (4.78)	28.63 (4.44)
Insurable wage (S.D.)	68062.77 (10046.61)	995.71 (27.46)	25343.25 (9976.96)
Aborigine (%)	37 (0.40%)	8,237 (5.90%)	15,544 (2.20%)
Hospital characteristics			
Bed size (S.D.)	871.72 (997.55)	377.47 (650.92)	504.95 (761.95)
Ownership			
Public (%)	1,715 (18.36%)	12,826 (9.19%)	80,741 (11.44%)
Private non-profit (%)	4,112 (44.01%)	34,311 (24.58%)	215,222 (30.49%)
Proprietary (%)	3,516 (37.63%)	92,428 (66.23%)	409,950 (58.07%)
Accreditation status			
Medical centers (%)	3,331 (35.65%)	17,426 (12.49%)	123,680 (17.52%)
Regional hospitals (%)	2,606 (27.89%)	29,353 (21.03%)	178,354 (25.27%)
District Hospitals (%)	1,966 (21.04%)	38,545 (27.62%)	178,743 (25.32%)
Clinics (%)	1,440 (15.41 %)	54,241 (38.86%)	225,136 (31.89%)
Teaching status			
Teaching (%)	7,000 (74.92%)	55,436 (39.72%)	350,031 (49.59%)
Non-teaching (%)	2,343 (25.08%)	84,129 (60.28%)	355,882 (50.41%)
Ob/gyn characteristics			
Gender (S.D.) (0 if female; 1 if male)	0.89 (0.31)	0.96 (0.19)	0.93 (0.25)
Ob/gyn age (S.D.)	40.62 (2.33)	39.44 (1.83)	39.48 (1.89)
Complications in c-section			
Fetal distress (%)	271 (2.90%)	3,755 (2.69%)	17,452 (2.47%)
Dystocia (%)	1,789 (19.15%)	25,074 (17.97%)	123,781 (17.53%)
Breech (%)	765 (8.19%)	10,585 (7.58%)	52,705 (7.47%)
Others (%)	815 (8.72%)	8,224 (5.89%)	42,971 (6.09%)
Previous c-section (%)	1,465 (15.68%)	19,623 (14.06%)	108,031 (15.30%)
Obs.	9,343	139,565	705,913

Table 9. Summary statistics of hospital and clinic characteristics, 1996-2004

Year	1996	1997	1998	1999	2000	2001	2002	2003	2004
Bed Size									
0-50 (%)	337 (43.80%)	330 (44.47%)	357 (51.15%)	369 (53.56%)	370 (57.54%)	355 (59.27%)	341 (60.04%)	331 (60.73%)	316 (61.00%)
51-100 (%)	37 (4.82%)	31 (4.18%)	28 (4.01%)	25 (3.62%)	23 (3.58%)	25 (4.17%)	19 (3.35%)	19 (3.49%)	23 (4.44%)
101-300 (%)	73 (9.52%)	74 (9.98%)	73 (10.46%)	76 (11.03%)	64 (9.95%)	53 (8.85%)	53 (9.33%)	43 (7.89%)	34 (6.56%)
>300 (%)	321 (41.80%)	307 (41.37%)	240 (34.38%)	219 (31.79%)	186 (28.93%)	166 (27.71%)	155 (27.28%)	152 (2.79%)	145 (28.00%)
Mean (S.D.)	135.99 (304.67)	148.17 (313.73)	144.02 (317.10)	144.03 (318.70)	151.33 (326.81)	160.57 (343.50)	172.84 (358.41)	181.33 (371.11)	186.92 (384.30)
Ownership									
Private (%)	644 (83.86%)	610 (82.21%)	574 (82.23%)	563 (81.71%)	523 (81.34%)	484 (80.80%)	453 (79.75%)	425 (77.98%)	410 (79.15%)
Non-profit (%)	55 (7.16%)	63 (8.49%)	57 (8.17%)	57 (8.27%)	56 (8.71%)	52 (8.68%)	52 (9.15%)	59 (10.82%)	56 (10.81%)
Public (%)	69 (8.98%)	69 (9.30%)	67 (9.60%)	69 (10.02%)	64 (9.95%)	63 (10.52%)	63 (11.10%)	61 (11.20%)	52 (10.04%)
Accreditation									
Medical centers (%)	14 (1.82%)	14 (1.87%)	14 (2.01%)	15 (2.20%)	16 (2.49%)	17 (2.83%)	17 (3.00%)	17 (3.12%)	17 (3.28%)
Regional hospital (%)	54 (7.03%)	52 (7.01%)	50 (7.17%)	51 (7.49%)	62 (9.64%)	62 (10.35%)	69 (12.15%)	69 (12.66%)	62 (11.97%)
District hospitals (%)	222 (28.91%)	218 (29.38%)	213 (30.56%)	215 (31.57%)	193 (30.02%)	173 (28.81%)	154 (27.11%)	148 (27.16%)	131 (25.89%)
Clinics (%)	478 (62.24%)	458 (61.72%)	421 (60.26%)	488 (58.74%)	372 (57.85%)	347 (57.92%)	326 (57.39%)	311 (57.06%)	308 (59.46%)
Teaching status									
Teaching	60 (7.81%)	133 (17.92%)	128(18.36%)	129 (18.72%)	126 (19.84%)	121 (20.20%)	125 (22.01%)	124 (22.75%)	119 (22.97%)
Non-teaching	708 (92.19%)	609 (82.08%)	569(81.64%)	560 (81.28%)	517 (80.16%)	479 (79.80%)	443 (77.99%)	421 (77.25%)	399 (77.03%)
Observations	768	742	698	689	643	599	568	545	518

Table 10. Summary statistics of ob/gyn characteristics, 1996-2004

Year	1996	1997	1998	1999	2000	2001	2002	2003	2004
Gender									
Male (%)	1,713 (91.17%)	1,539 (91.34%)	1,528(91.72%)	1,519 (91.68%)	1,462 (90.58%)	1,462 (89.97%)	1,440 (%)	1,409 (88.39%)	1,393 (%)
Female (%)	166 (8.83%)	146 (8.66%)	138 (8.28%)	138 (8.32%)	152 (9.42%)	163 (10.03%)	174 (%)	185 (11.61%)	194 (%)
Age									
26-30 (%)	36 (1.92%)	19 (1.29%)	16 (0.97%)	18 (1.09%)	23 (1.43%)	14 (0.86%)	10 (0.62%)	13 (0.80%)	18 (1.13%)
31-40 (%)	760 (40.45%)	648 (38.46%)	631(37.88%)	602 (36.33%)	538 (33.33%)	496 (30.52%)	472 (29.24%)	443 (27.79%)	404 (25.46%)
41-50 (%)	786 (41.83%)	749 (44.45%)	702 (42.15%)	705 (42.55%)	724 (44.86%)	745 (45.85%)	728 (45.11%)	692 (43.41%)	705 (44.42%)
>50 (%)	284 (1.50%)	269 (1.60%)	317 (1.90%)	322 (19.43%)	329 (20.38%)	370 (22.77%)	404 (25.03%)	432 (27.10%)	460 (28.99%)
Mean (S.D.)	42.89 (8.52)	43.51 (8.15)	43.81 (8.18)	44.10 (8.11)	44.41 (7.98)	44.91 (7.87)	45.27 (7.85)	45.58 (8.01)	45.79 (8.06)
Years in ob/gyn specialty									
0-5 (%)	475 (25.28%)	429 (25.46%)	404 (24.25%)	371 (22.39%)	410 (25.40%)	400 (24.62%)	259 (16.05%)	241 (15.12%)	213 (13.42%)
6-10 (%)	1,202 (63.97%)	1,143 (67.83%)	1,098 (65.91%)	949 (57.27%)	960 (59.48%)	994 (61.17%)	889 (55.08%)	822 (51.57%)	746 (47.01%)
>10 (%)	202 (10.75%)	113 (6.71%)	164 (9.84%)	337 (20.38%)	244 (15.12%)	231 (14.22%)	466 (28.87%)	531 (33.31%)	628 (39.57%)
Mean (S.D.)	6.38 (2.77)	6.87 (2.92)	7.45 (3.17)	8.06 (3.38)	8.66 (3.64)	9.25 (3.86)	9.88 (4.07)	10.43 (4.34)	10.99 (4.47)
Observations	1,879	1,685	1,666	1,657	1,614	1,625	1,614	1,594	1,587

Table 11. The effect of declining fertility on ob/gyns' revenue

Year	Number of attending ob/gyns	Average number of singleton deliveries performed	Average revenue from singleton deliveries (in NT$)
1996	1,879	177.22	3,343,926.08
1997	1,685	186.43	3,653,196.72
1998	1,666	153.58	3,088,646.87
1999	1,657	159.92	3,244,554.32
2000	1,614	172.50	3,504,260.61
2001	1,625	144.14	2,958,485.39*
2002	1,614	137.25	2,864,625.75*
2003	1,594	134.95	2,992,693.05*
2004	1,587	135.66	3,162,313.78*
Total	3,044		

Notes: *Due to the implementation of global budgeting, those numbers are the points of worth for singleton deliveries, and they need to be adjusted by the dollar value per service point. So the actual revenue will be lower than the numbers listed.

Table 12. The effect of declining fertility on hospitals' and clinics' revenue

Year	Number of hospitals/clinics	Average number of singleton deliveries performed	Average revenue from singleton deliveries (in NT$)
1996	768	390.68	7,371,441.20
1997	742	402	7,877,513.14
1998	698	345.01	6,938,392.96
1999	689	362.77	7,360,287.95
2000	643	415.55	8,441,834.67
2001	599	370.57	7,606,122.69*
2002	568	371.64	7,756,680.29*
2003	545	374.40	8,302,664.03*
2004	518	404.64	9,431,997.67*
Total	1,182		

Notes: *Due to the implementation of global budgeting, those numbers are the points of worth for singleton deliveries, and they need to be adjusted by the dollar value per service point. So the actual revenue will be lower than the numbers listed.

Table 13. Volumes and LOS of tocolysic hospitalizations, 1996-2004

Year	Total volume	Average LOS	Mean ob/gyn level volume	Mean hospital and clinic level volume
1996	8,810	5.94 (7.86)	11.16 (13.70)	37.81 (84.57)
1997	9,145	6.27 (8.77)	11.61 (14.20)	38.91 (84.69)
1998	9,006	6.11 (9.12)	10.71 (13.30)	35.73 (73.80)
1999	10,217	6.21 (8.45)	11.47 (14.13)	36.88 (76.38)
2000	10,564	6.68 (9.61)	11.47 (14.52)	36.68 (75.24)
2001	9,174	6.87 (9.38)	10.09 (11.96)	34.35 (61.72)
2002	9,362	6.85 (9.74)	10.22 (12.09)	36.28 (64.61)
2003	8,232	7.43 (10.53)	9.41 (11.41)	32.92 (56.76)
2004	9,098	7.70 (10.83)	10.39 (12.43)	37.60 (63.11)
Obs.	215,663		1684	508

Notes: Volume is defined as the number of hospitalizations in a year. Standard deviation in parentheses.

Table 14. Total and mean revenues of tocolysic hospitalizations, 1996-2004

Year	Total revenue	Mean ob/gyn level revenue	Mean hospital and clinic level revenue
1996	377,009,258	148,431.73 (265,980.87)	502,629.34 (170,5415.11)
1997	364,835,812	157,001.29 (253,761.78)	526,455.40 (157,6969.94)
1998	400,660,983	142,946.03 (222,928.28)	477,054.03 (129,4140.74)
1999	445,777,358	158,192.13 (273,083.75)	508,841.82 (144,3203.01)
2000	453,337,210	165,691.29 (295,027.32)	529,866.94 (155,5137.36)
2001	423,273,599	152,658.26 (252,659.78)	519,724.19 (142,3276.05)
2002	426,469,142	157,025.88 (279,310.18)	557,502.72 (153,9934.48)
2003	413,894,239	154,092.17 (259,844.41)	539,322.59 (133,4521.09)
2004	461,554,116	182,177.66 (305,670.36)	659,453.02 (154,8756.16)
Obs.	215,663	1684	508

Notes: Standard deviation in parentheses.

Table 15. Probit estimates of the effect of fertility on the probability of having c-sections (for Equations (1) and (2))

	Dependent variable =1 if having c-section					
	Specification 1		Specification 2		Specification 3	
Variables	Coef.	Robust Std. Err.	Coef.	Robust Std. Err.	Coef.	Robust Std. Err.
Main explanatory variables						
Log general fertility rate	-0.274**	0.114				
Log ob/gyn per 100 births			0.173***	0.038	0.155***	0.036
Patients' characteristics						
Age	0.027***	0.001	0.027***	0.001	0.027***	0.001
Insurable wage ($\div 10^2$)	-0.0002***	0.00001	-0.0002***	0.00001	-0.0002***	0.00001
Aborigine	-0.069***	0.015	-0.069***	0.016	-0.068***	0.016
Previous c-section	3.571***	0.010	3.564***	0.011	3.564***	0.011
Fetal distress	2.572***	0.016	2.559***	0.016	2.559***	0.016
Dystocia	3.108***	0.009	3.123***	0.009	3.123***	0.009
Breech	0.683***	0.018	0.665***	0.018	0.665***	0.018
Other complications	1.859***	0.010	1.852***	0.010	1.852***	0.010
Hospitals' characteristics						
Private non-profit	-0.160***	0.010	-0.155***	0.010	-0.155***	0.010
Proprietary	0.213***	0.012	0.215***	0.012	0.214***	0.012
Medical center	0.117***	0.020	0.126***	0.021	0.127***	0.021
Regional Hospital	-0.115***	0.013	-0.113***	0.013	-0.112***	0.013
District Hospital	0.042***	0.007	0.045***	0.007	0.045***	0.007
Teaching Hospital	0.069***	0.011	0.067***	0.011	0.066***	0.011
Bed size ($\div 10^2$)	-0.007***	0.001	-0.007***	0.001	-0.007***	0.001
Ob/gyn characteristics						
Ob/gyn age	-0.003*	0.002	-0.003*	0.002	-0.004*	0.002
Ob/gyn gender	0.018*	0.010	0.020*	0.010	0.019*	0.010
Constant	-1.297**	0.448	-2.533***	0.085	-2.326	0.074
Log likelihood	-163,935.43		-160,193.25		-160,194.24	
Marginal effect of the main explanatory variable (s.e.)	-0.102** (0.042)		0.064*** (0.014)		0.057***(0.011)	

Notes: All probit regressions include a full set of time and regional dummies. $N = 854,820$. *Statistically significant at the 10% level. **Statistically significant at the 5% level. ***Statistically significant at the 1% level. In specification 3, the numerator of the main explanatory variable is the lag of number of on/gyns in each region to control for the potential endogeneity of the variable log ob/gyn per 100 births.

Table 16. Robustness check for Table 15.

	Dependent variable =1 if having c-section							
	Specification 1		Specification 2		Specification 3		Specification 4	
Variables	Coef.	Robust Std. Err.	Coef.	Robust Std. Err.	Coef.	Robust Std. Err.	Coef.	Robust Std. Err.
Main explanatory variables								
Log general fertility rate	-0.168**	0.085	-.137**	0.067				
Log ob/gyn per 100 births					0.277**	0.138	0.182**	0.098
Patients' characteristics								
Age	0.027***	0.001	0.026***	0.001	0.027***	0.001	0.027***	0.001***
Insurable wage ($\div 10^2$)	-0.0002***	0.00002	-0.0002***	0.00002	-0.0002***	0.00002	-0.0002***	0.00002
Aborigine	-0.112***	0.015	-0.063***	0.015	-0.068***	0.016	-0.063***	0.016
Previous c-section	3.554***	0.009	3.696***	0.009	3.566***	0.009	3.691***	0.010
Fetal distress	2.556***	0.014	2.717***	0.014	2.561***	0.014	2.706***	0.014
Dystocia	3.099***	0.008	3.277***	0.009	3.125***	0.008	3.297***	0.009
Breech	0.683***	0.016	0.681***	0.016	0.665***	0.016	0.660***	0.016
Other complications	1.847***	0.008	2.004**	0.009	1.854***	0.008	2.001***	0.009
Hospitals' characteristics								
Private non-profit	-0.162***	0.009	-3.546	14.001	-0.155***	0.009	3.154	27.410
Proprietary	0.209***	0.011	-6.317	30.854	0.219***	0.011	0.391	2.528
Medical center	0.136***	0.018	-0.025	0.027	0.128***	0.018	2.229	27.404
Regional Hospital	-0.074***	0.012	-5.900	30.858	-0.112***	0.013	0.819	2.576
District Hospital	0.027***	0.006	-2.502	13.983	0.046***	0.008	2.395	27.321
Teaching Hospital	0.018*	0.011	-3.546	14.001	0.070***	0.011	-0.032	0.029
Bed size ($\div 10^2$)	-0.006***	0.001	0.015**	0.006	-0.007***	0.001	0.018**	0.006
Ob/gyn characteristics								
Ob/gyn age	-0.014	0.103	-0.003**	0.002	-0.003	0.002	-0.003**	0.002
Ob/gyn gender	1.557	7.392	0.016	0.011	0.019	0.090	0.001	0.103
Constant	0.033	5.782	2.270	14.018	-2.051***	0.101	-4.960	27.404
Include hospital fixed effects	No		Yes		No		Yes	
Include ob/gyn fixed effects	Yes		No		Yes		No	
Include regional fixed effects	No		No		No		No	
Log likelihood	-150,003.09		-153,035.65		-150,051.38		-149,378.76	

Notes: All probit regressions include a full set of time dummies. N = 833,276 for specification 2 and 4, and 795,988 for specification 1 and 3. *Statistically significant at the 10% level. **Statistically significant at the 5% level. ***Statistically significant at the 1% level.

Table 17. Multinomial logit (MNL) estimates for equation (5): the effect of declining fertility on the probability of having c-sections and CDMR (Base outcome: vaginal delivery)

	C-section		C-section on maternal request	
Variables	Coef.	Robust Std. Err.	Coef.	Robust Std. Err.
Main explanatory variable				
Log general fertility rate	-0.086	0.269	-0.787**	0.350
Patients' characteristics				
Age	0.056***	0.001	0.055***	0.002
Insurable wage ($\div 10^2$)	-.0004***	.00004	-0.0004***	0.0001
Aborigine	-0.067*	0.036	-0.371***	0.061
Previous c-section	7.617***	0.024	3.211***	0.032
Fetal distress	5.644***	0.028	1.489***	0.069
Dystocia	6.568***	0.019	2.695***	0.031
Breech	1.592***	0.038	0.428***	0.064
Other complications	4.432***	0.019	1.092***	0.036
Hospitals' characteristics				
Private non-profit	-0.548***	0.023	0.189***	0.031
Proprietary	0.170***	0.029	1.142***	0.043
Medical Center	0.109**	0.047	0.573***	0.062
Regional Hospital	-0.424***	0.030	0.117**	0.045
District Hospital	-0.173***	0.016	0.475***	0.022
Teaching Hospital	0.149***	0.027	0.074**	0.034
Bed size ($\div 10^2$)	-0.027***	0.002	-0.0004	0.002
Ob/gyn characteristics				
Ob/gyn age	-0.005	0.004	-0.014	0.006**
Ob/gyn gender	-0.003	0.024	0.124***	0.034
Constant	-4.932***	1.055	-2.263	1.378
Log likelihood	-199,467.89			
Marginal effect of the main explanatory variable (s.e.)	-0.006 (0.047)		-0.036** (0.016)	

Notes: The MNL regression includes a full set of time and regional dummies. *N* = 854,820. *Statistically significant at the 10% level. **Statistically significant at the 5% level. ***Statistically significant at the 1% level.

Table 18. Multinomial logit (MNL) estimates for equation (5): the effect of declining fertility on the probability of having c-sections and CDMR (Base outcome: vaginal delivery)

	C-section		C-section on maternal request	
Variables	Coef.	Robust Std. Err.	Coef.	Robust Std. Err.
Main explanatory variable				
Log ob/gyn per 100 births	-0.0001	0.087	0.791***	0.130
Patients' characteristics				
Age	0.057***	0.001	0.055***	0.002
Insurable wage ($\div 10^2$)	-0.0004***	0.0001	-0.0004***	0.0001
Aborigine	-0.069*	0.036	-0.375***	0.062
Previous c-section	7.601***	0.025	3.214***	0.032
Fetal distress	5.617***	0.029	1.488***	0.069
Dystocia	6.598***	0.020	2.735***	0.031
Breech	1.555***	0.039	0.400***	0.064
Other complications	4.417***	0.019	1.090***	0.036
Hospitals' characteristics				
Private non-profit	-0.538***	0.023	0.197***	0.032
Proprietary	0.150***	0.029	1.178***	0.043
Medical Center	0.156**	0.048	0.579***	0.063
Regional Hospital	-0.409***	0.031	0.122**	0.045
District Hospital	-0.158***	0.017	0.469***	0.022
Teaching Hospital	0.133***	0.027	0.084**	0.034
Bed size ($\div 10^2$)	-0.028***	0.002	0.00004	0.002
Ob/gyn characteristics				
Ob/gyn age	-0.005	0.004	-0.014**	0.006
Ob/gyn gender	0.001	0.023	0.125***	0.034
Constant	-5.268***	0.178	-5.140***	.250
Log likelihood	-195,381.97			
Marginal effect of the main explanatory variable (s.e.)	-0.009 (0.015)		0.037*** (0.006)	

Notes: The MNL regression includes a full set of time and regional dummies. N = 854,820. *Statistically significant at the 10% level. **Statistically significant at the 5% level. ***Statistically significant at the 1% level.

Table 19. Probit estimates for equation (3): the effects of declining fertility and health information gap on the probability of having c-sections (Base outcome: vaginal delivery)

	Specification 1 (Comparison group: female physicians and female relatives of physicians; Treatment group: other women)		Specification 2 (Comparison group: high socioeconomic status women; Treatment group: low socioeconomic status women)	
Variables	Coef.	Robust Std. Err.	Coef.	Robust Std. Err.
Log general fertility rate	-0.276**	0.114	-0.052	0.281
Log general fertility rate $\times$ Information	0.026	0.140	0.425**	0.173
Information	-0.188	0.513	-1.746**	0.655
Patients' characteristics				
Age	0.027***	0.001	.027***	.001
Insurable wage ($\div 10^2$)	-.0002***	.00002	0.0003	0.0002
Aborigine	-0.069***	0.016	-0.153***	0.028
Previous c-section	3.571***	0.011	3.524***	0.026
Fetal distress	2.572***	0.016	2.563***	0.040
Dystocia	3.108***	0.010	3.075***	0.022
Breech	0.684***	0.018	0.587***	0.040
Other complications	1.858***	0.010	1.878***	0.023
Hospitals' characteristics				
Private non-profit	-0.160***	0.010	-0.196***	0.024
Proprietary	0.212***	0.012	0.195***	0.029
Medical center	0.117***	0.020	0.197	0.050
Regional Hospital	-0.115***	0.013	-0.049	0.032
District Hospital	0.042***	0.007	0.098	0.015
Teaching Hospital	0.069***	0.011	0.051*	0.027
Bed size ($\div 10^2$)	-0.007***	0.001	-0.007	0.002
Ob/gyn characteristics				
Ob/gyn age	-0.002	0.002	0.002	0.004
Ob/gyn gender	0.018*	0.010	0.065**	.028
Constant	-1.354**	0.449	-2.306**	1.098
Log likelihood	-199,462.47		-37,811.01	

Notes: All probit regressions include a full set of time and regional dummies. *N*= 854,820 for speciation1 and 148,908 for specification 2. *Statistically significant at the 10% level. **Statistically significant at the 5% level. ***Statistically significant at the 1% level.

The marginal effect of the interaction term "Log general fertility rate $\times$ Information" on the probability of having c-sections (for specification 1):

$$\begin{bmatrix} (Pr(LGFR = 3.5835189, I = 0)) \\ -(Pr(LGFR = 3.871201, I = 0)) \end{bmatrix} - \begin{bmatrix} (Pr(LGFR = 3.5835189, I = 1)) \\ -(Pr(LGFR = 3.871201, I = 1)) \end{bmatrix}$$

$$= [(0.3564067) - (0.3481677)] - [(0.3465161) - (0.3394421)] = 0.0011651$$

Standard error for the marginal effect obtained by bootstrapping: 0.0010784

The marginal effect of the interaction term "Log general fertility rate $\times$ Information" on the probability of having c-sections (for specification 2):

$$\begin{bmatrix} (Pr(LGFR = 3.5835189, I = 0)) \\ -(Pr(LGFR = 3.871201, I = 0)) \end{bmatrix} - \begin{bmatrix} (Pr(LGFR = 3.5835189, I = 1)) \\ -(Pr(LGFR = 3.871201, I = 1)) \end{bmatrix}$$

$$= [(0.3712144) - (0.3694662)] - [(0.3465317) - (0.357889)] = 0.131095$$

Standard error for the marginal effect obtained by bootstrapping: 0.0131095

Table 20. Probit estimates for equation (4): the effects of declining fertility and health information gap on the probability of having c-sections (Base outcome: vaginal delivery)

	Specification 1 (Comparison group: female physicians and female relatives of physicians; Treatment group: other women)		Specification 2 (Comparison group: high socioeconomic status women; Treatment group: low socioeconomic status women)	
Variables	Coef.	Robust Std. Err.	Coef.	Robust Std. Err.
Log ob/gyn per 100 births	0.174***	0.038	0.339***	0.091
Log ob/gyn per 100 births $\times$ Information	-0.008	0.134	-0.293**	0.106
Information	-0.103*	0.057	-0.304	0.164
Patients' characteristics				
Age	0.027***	0.001	0.027***	0.001
Insurable wage ($\div 10^2$)	-0.0002***	0.0002	0.0003	0.0002
Aborigine	-0.069***	0.016	-0.152***	0.028
Previous c-section	3.564***	0.011	3.517***	0.026
Fetal distress	2.559***	0.016	2.555***	0.040
Dystocia	3.123***	0.009	3.081***	0.022
Breech	0.665***	0.018	0.573***	0.040
Other complications	1.852***	0.010	1.869***	0.023
Hospitals' characteristics				
Private non-profit	-0.155***	0.010	-0.187***	0.025
Proprietary	0.214***	0.012	0.203***	0.029
Medical center	0.127***	0.021	0.188***	0.050
Regional Hospital	-0.113***	0.013	-0.050	0.032
District Hospital	0.045***	0.007	0.100***	0.015
Teaching Hospital	0.068***	0.011	0.048*	0.027
Bed size ($\div 10^2$)	-0.007***	0.001	-0.007	0.002
Ob/gyn characteristics				
Ob/gyn age	-0.002	0.002	0.002	0.004
Ob/gyn gender	0.020*	0.010	0.066**	0.029
Constant	-2.390***	0.079	-2.413	0.160
Log likelihood	-160,195.98		-30,235.683	

Notes: All probit regressions include a full set of time and regional dummies. *N*= 854,820 for speciation1 and 148,908 for specification 2. *Statistically significant at the 10% level. **Statistically significant at the 5% level. ***Statistically significant at the 1% level.

The marginal effect of the interaction term "Log ob/gyn per 100 births $\times$ Information" on the probability of having c-sections (for specification 1):

$$\begin{bmatrix} (Pr(LOBBIRTH = -0.3206919, I = 0)) \\ -(Pr(LOBBIRTH = -0.5523823, I = 0)) \end{bmatrix} - \begin{bmatrix} (Pr(LOBBIRTH = -0.3206919, I = 1)) \\ -(Pr(LOBBIRTH = -0.5523823, I = 1)) \end{bmatrix}$$

$$= [(0.3553488) - (0.3511582)] - [(0.3450954) - (0.3413412)] = 0.0004363$$

Standard error for the marginal effect obtained by bootstrapping: 0.000551

The marginal effect of the interaction term "Log ob/gyn per 100 births $\times$ Information" on the probability of having c-sections (for specification 2):

$$\begin{bmatrix} (Pr(LOBBIRTH = -0.3206919, I = 0)) \\ -(Pr(LOBBIRTH = -0.5523823, I = 0)) \end{bmatrix} - \begin{bmatrix} (Pr(LOBBIRTH = -0.3206919, I = 1)) \\ -(Pr(LOBBIRTH = -0.5523823, I = 1)) \end{bmatrix}$$

$$= [(0.3747486) - (0.3654723)] - [(0.3509932) - (0.3498897)] = 0.0081728$$

Standard error for the marginal effect obtained by bootstrapping: 0.0054824

Table 21. MNL estimates of the effects of declining fertility and health information gap (Base outcome: vaginal delivery; Comparison group: female physicians and female relatives of physicians; Treatment group: other women)

	C-section		C-section on maternal request	
Variables	Coef.	Robust Std. Err.	Coef.	Robust Std. Err.
Log general fertility rate	-0.090	0.270	-0.789**	0.350
Log general fertility rate × Information	-0.030	0.320	-0.044	0.467
Information	-0.133	1.175	0.048	1.687
Patients' characteristics				
Age	0.056***	0.001	.055***	0.002
Insurable wage ($\div 10^2$)	-0.0004***	.00005	-.0004***	0.0001
Aborigine	-0.067*	0.035	-.371***	0.061
Previous c-section	7.617***	0.025	3.211***	0.032
Fetal distress	5.644***	0.028	1.488***	0.069
Dystocia	6.568***	0.019	2.695***	0.031
Breech	1.593***	0.038	0.428***	0.063
Other complications	4.432***	0.019	1.092***	.036
Hospitals' characteristics				
Private non-profit	-0.550***	0.023	0.188***	0.031
Proprietary	-0.169***	0.029	1.142***	0.043
Medical Center	0.111**	0.047	0.574***	0.062
Regional Hospital	-0.424***	0.031	0.117**	0.045
District Hospital	-0.173***	-0.016	0.475***	0.022
Teaching Hospital	0.149***	0.027	0.074**	0.034
Bed size ($\div 10^2$)	-0.027***	0.002	-.0004	.002
Ob/gyn characteristics				
Ob/gyn age	-0.001	0.005	-0.012*	0.006
Ob/gyn gender	-0.001	0.024	0.124***	0.034
Constant	-5.083***	1.058	-2.339*	1.380
Log likelihood	-199,462.47			

Notes: The MNL regression includes a full set of time and regional dummies. N = 854,820. *Statistically significant at the 10% level. **Statistically significant at the 5% level. ***Statistically significant at the 1% level.

The marginal effect of the interaction term "Log general fertility rate × Information" on the probability of having c-sections:

$$\begin{bmatrix}(Pr(LGFR = 3.5835189, I = 0)) \\ -(Pr(LGFR = 3.871201, I = 0))\end{bmatrix} - \begin{bmatrix}(Pr(LGFR = 3.5835189, I = 1)) \\ -(Pr(LGFR = 3.871201, I = 1))\end{bmatrix}$$

$$= [(0.329908) - (0.3301604)] - [(0.3217674) - (0.3218358)] = -0.000184$$

Standard error for the marginal effect obtained by bootstrapping: 0.0005024

The marginal effect of the interaction term "Log general fertility rate $\times$ Information" on the probability of having CDMR:

$$\begin{bmatrix}(Pr(LGFR = 3.5835189, I = 0)) \\ -(Pr(LGFR = 3.871201, I = 0))\end{bmatrix} - \begin{bmatrix}(Pr(LGFR = 3.5835189, I = 1)) \\ -(Pr(LGFR = 3.871201, I = 1))\end{bmatrix}$$

$$= [(0.0255031) - (0.0206373)] - [(0.243235) - (0.01949)] = 0.0000322$$

Standard error for the marginal effect obtained by bootstrapping: 0.0004027

Table 22. MNL estimates of the effects of declining fertility and health information gap (Base outcome: vaginal delivery; Comparison group: female physicians and female relatives of physicians; Treatment group: other women)

	C-section		C-section on maternal request	
		Robust		Robust
Variables	Coef.	Std. Err.	Coef.	Std. Err.
Log ob/gyn per 100 births	0.0002	0.087	0.791***	0.130
Log ob/gyn per 100 births × Information	0.133	0.291	-0.054	0.390
Information	-0.218	0.128	-0.127	0.150
Patients' characteristics				
Age	0.057***	0.001	0.055***	0.002
Insurable wage ($\div 10^2$)	-.0004***	.00005	-0.0003***	0.0001
Aborigine	-0.069*	0.036	-0.375***	0.062
Previous c-section	7.601***	0.025	3.215***	0.031
Fetal distress	5.617***	0.028	1.488***	0.069
Dystocia	6.599***	0.020	2.735***	0.036
Breech	1.555***	0.039	0.400***	0.064
Other complications	4.417***	0.019	1.090***	0.031
Hospitals' characteristics				
Private non-profit	-0.540***	0.023	0.196***	0.032
Proprietary	0.149***	0.029	1.177***	0.043
Medical Center	0.157**	0.048	0.580***	0.063
Regional Hospital	-0.408***	0.031	0.123**	0.045
District Hospital	-0.157***	.017	0.469***	0.022
Teaching Hospital	0.133***	0.027	0.084**	0.034
Bed size ($\div 10^2$)	-0.028***	0.002	0.00004	0.002
Ob/gyn characteristics				
Ob/gyn age	-0.001	0.005	-0.012*	0.006
Ob/gyn gender	0.003	0.024	0.126***	0.034
Constant	-5.446***	.190	-5.219***	0.262
Log likelihood	-197,158.7			

Notes: The MNL regression includes a full set of time and regional dummies. N = 854,820. *Statistically significant at the 10% level. **Statistically significant at the 5% level. ***Statistically significant at the 1% level.

The marginal effect of the interaction term "Log ob/gyn per 100 births × Information" on the probability of having c-sections:

$$\begin{bmatrix} (Pr(LOBBIRTH = -0.3206919, I = 0)) \\ -(Pr(LOBBIRTH = -0.5523823, I = 0)) \end{bmatrix} - \begin{bmatrix} (Pr(LOBBIRTH = -0.3206919, I = 1)) \\ -(Pr(LOBBIRTH = -0.5523823, I = 1)) \end{bmatrix}$$

$$= [(0.3294064) - (0.3304032)] - [(0.320548) - (0.3204296)] = -0.0011152$$

Standard error for the marginal effect obtained by bootstrapping: 0.0016407

The marginal effect of the interaction term "Log ob/gyn per 100 births × Information" on the probability of having CDMR:

$$\begin{bmatrix} (Pr(LOBBIRTH = -0.3206919, I = 0)) \\ -(Pr(LOBBIRTH = -0.5523823, I = 0)) \end{bmatrix} - \begin{bmatrix} (Pr(LOBBIRTH = -0.3206919, I = 1)) \\ -(Pr(LOBBIRTH = -0.5523823, I = 1)) \end{bmatrix}$$

$$= [(0.0260469) - (0.0218672)] - [(0.0249675) - (0.0213742)] = 0.0005563$$

Standard error for the marginal effect obtained by bootstrapping: 0.0005085

Table 23. MNL estimates of the effects of declining fertility and health information gap (Base outcome: vaginal delivery; Comparison group: high socioeconomic status women; Treatment group: low socioeconomic status women)

	C-section		C-section on maternal request	
		Robust		Robust
Variables	Coef.	Std. Err.	Coef.	Std. Err.
Log general fertility rate	0.966	0.681	-1.127	0.810
Log general fertility rate × Information	0.671	0.422	1.341**	0.454
Information	-2.668*	1.580	-5.233**	1.702
Patients' characteristics				
Age	0.053***	0.003	0.060***	0.003
Insurable wage ($\div 10^2$)	0.0002	0.0006	0.001	0.001
Aborigine	-0.236***	0.063	-0.497***	0.101
Previous c-section	7.570***	0.060	3.052***	0.078
Fetal distress	5.677***	0.067	1.458***	0.157
Dystocia	6.538***	0.045	2.636***	0.069
Breech	1.384***	0.086	0.313**	0.138
Other complications	4.492***	0.044	0.969***	0.083
Hospitals' characteristics				
Private non-profit	-0.670***	0.061	0.124*	0.070
Proprietary	0.089	0.073	0.988***	0.093
Medical Center	0.325**	0.118	0.629***	0.137
Regional Hospital	-0.281***	0.075	0.255**	0.098
District Hospital	-0.098**	0.037	0.589***	0.046
Teaching Hospital	0.101	0.065	-0.010	0.074
Bed size ($\div 10^2$)	-.030***	0.005	0.001	0.005
Ob/gyn characteristics				
Ob/gyn age	0.006	0.010	0.002	0.011
Ob/gyn gender	0.091	0.067	0.152	0.084
Constant	-9.240**	2.660	-1.318	3.168
Log likelihood	-37,811			

Notes: The MNL regression includes a full set of time and regional dummies. $N = 148{,}908$.
*Statistically significant at the 10% level. **Statistically significant at the 5% level. ***Statistically significant at the 1% level.
The marginal effect of the interaction term "Log general fertility rate × Information" on the probability of having c-sections:

$$\begin{bmatrix}(Pr(LGFR = 3.5835189, I = 0)) \\ -(Pr(LGFR = 3.871201, I = 0))\end{bmatrix} - \begin{bmatrix}(Pr(LGFR = 3.5835189, I = 1)) \\ -(Pr(LGFR = 3.871201, I = 1))\end{bmatrix}$$
$$= [(0.3295949) - (0.3420091)] - [(0.3225041) - (0.3395174)] = 0.0046589$$

Standard error for the marginal effect obtained by bootstrapping: 0.0079384

The marginal effect of the interaction term "Log general fertility rate $\times$ Information" on the probability of having CDMR:

$$\begin{bmatrix}(Pr(LGFR = 3.5835189, I = 0)) \\ -(Pr(LGFR = 3.871201, I = 0))\end{bmatrix} - \begin{bmatrix}(Pr(LGFR = 3.5835189, I = 1)) \\ -(Pr(LGFR = 3.871201, I = 1))\end{bmatrix}$$
$$= [(0.0338731) - (0.0235056)] - [(0.0239716) - (0.022908)] = 0.009304$$

Standard error for the marginal effect obtained by bootstrapping: 0.0081543

Table 24. MNL estimates of the effects of declining fertility and health information gap (Base outcome: vaginal delivery; Comparison group: high socioeconomic status women; Treatment group: low socioeconomic status women)

	C-section		C-section on maternal request	
Variables	Coef.	Robust Std. Err.	Coef.	Robust Std. Err.
Log ob/gyn per 100 births	0.237	0.209	1.257***	0.294
Log ob/gyn per 100 births × Information	-0.491	0.252	-0.773	0.374
Information	-0.422	0.392	-0.625**	0.253
Patients' characteristics				
Age	0.053***	0.003	0.058***	0.003
Insurable wage ($\div 10^2$)	0.0002	0.000	0.001	0.001
Aborigine	-0.234***	0.063	-0.499***	0.101
Previous c-section	7.553***	0.060	3.056***	0.078
Fetal distress	5.657***	0.068	1.460***	0.157
Dystocia	6.551***	0.046	2.648***	0.070
Breech	1.353***	0.086	0.303**	0.139
Other complications	4.479***	0.045	0.949***	0.084
Hospitals' characteristics				
Private non-profit	-0.653***	0.061	0.139**	0.070
Proprietary	0.087	0.074	1.041***	0.094
Medical Center	0.332**	0.119	0.612***	0.137
Regional Hospital	-0.275***	0.075	0.263**	0.099
District Hospital	-0.088**	0.037	0.585***	0.047
Teaching Hospital	0.084	0.065	0.003	0.074
Bed size ($\div 10^2$)	-.030***	.005	0.003	0.005
Ob/gyn characteristics				
Ob/gyn age	0.005	0.010	0.003	0.011
Ob/gyn gender	0.097	0.067	0.148*	0.084
Constant	-5.408***	0.403	-5.396***	0.458
Log likelihood	-37,127.577			

Notes: The MNL regression includes a full set of time and regional dummies. $N = 148{,}908$

*Statistically significant at the 10% level. **Statistically significant at the 5% lev el. ***Statistically significant at the 1% level.

The marginal effect of the interaction term "Log ob/gyn per 100 births × Information" on the probability of having c-sections:

$$\begin{bmatrix} (Pr(LOBBIRTH = -0.3206919, I = 0)) \\ -(Pr(LOBBIRTH = -0.5523823, I = 0)) \end{bmatrix} - \begin{bmatrix} (Pr(LOBBIRTH = -0.3206919, I = 1)) \\ -(Pr(LOBBIRTH = -0.5523823, I = 1)) \end{bmatrix}$$
$$= [(0.334121) - (0.3338365)] - [(0.3265658) - (0.3293346)] = 0.0030532$$

Standard error for the marginal effect obtained by bootstrapping: 0.0045163

The marginal effect of the interaction term "Log ob/gyn per 100 births $\times$ Information" on the probability of having CDMR:

$$\begin{bmatrix} (Pr(LOBBIRTH = -0.3206919, I = 0)) \\ -(Pr(LOBBIRTH = -0.5523823, I = 0)) \end{bmatrix} - \begin{bmatrix} (Pr(LOBBIRTH = -0.3206919, I = 1)) \\ -(Pr(LOBBIRTH = -0.5523823, I = 1)) \end{bmatrix}$$
$$= [(0.0337773) - (0.0259457)] - [(0.0250283) - (0.0221876)] = 0.0049909$$

Standard error for the marginal effect obtained by bootstrapping: 0.0047034

Table 25. Discrete Factor Model with Two Points of Support for Equation (1) and (2)

Variables	Specification 1 Coef.	Specification 1 Robust Std. Err.	Specification 2 Coef.	Specification 2 Robust Std. Err.
Main explanatory variables				
Log general fertility rate	-0.273**	0.111		
Log ob/gyn per 100 births			0.173***	0.038
Patients' characteristics				
Age	0.027***	0.001	0.027***	0.001
Insurable wage ($\div 10^2$)	-.0002***	.00002	-.0002***	0.00002
Aborigine	-0.069***	0.016	-0.069***	0.016
Previous c-section	3.564***	0.009	3.564***	0.009
Fetal distress	2.559***	0.014	2.559***	0.014
Dystocia	3.123***	0.008	3.123***	0.008
Breech	0.665***	0.016	0.665***	0.016
Other complications	1.852***	0.008	1.852***	0.008
Hospitals' characteristics				
Private non-profit	-0.155***	0.009	-0.155***	0.008
Proprietary	0.214***	0.011	0.215***	0.011
Medical Center	0.127***	0.018	0.126***	0.018
Regional Hospital	-0.112***	0.013	-0.113***	0.013
District Hospital	0.045***	0.008	0.045***	0.008
Teaching Hospital	0.066***	0.011	0.068***	0.011
Bed size ($\div 10^2$)	-0.007***	0.001	-0.007***	0.001
Ob/gyn characteristics				
Ob/gyn age	-0.003**	0.002	-0.004**	0.001
Ob/gyn gender	0.019*	0.010	0.019*	0.010
Constant	-1.303**	0.434	-2.320	0.063
Log likelihood	-160,200.24		-160,104.17	

Notes: Both specification 1 and specification 2 include a full set of time and regional dummies. N = 854,820. *Statistically significant at the 10% level. **Statistically significant at the 5% level. ***Statistically significant at the 1% level.

LR test for specification 1 (H_0: all $\mu_i = 0$):

$$LR = 2\left[\ln L\left(\hat{\theta}_u\right) - \ln L\left(\tilde{\theta}_r\right)\right] = -2\left[\left(-160{,}200.24\right) - \left(-163{,}935.43\right)\right] = 7470.78$$

LR test for specification 2 (H_0: all $\mu_i = 0$):

$$LR = -2\left[ln\, L\left(\hat{\theta}_u\right) - ln\, L\left(\tilde{\theta}_r\right)\right] = 2\left[\left(-160{,}104.17\right) - \left(-160.193.25\right)\right] = 7662.52$$

Table 26. Discrete Factor Model with Two Points of Support for Equation (5)

	C-section		C-section on maternal request	
Variables	Coef.	Robust Std. Err.	Coef.	Robust Std. Err.
Main explanatory variable				
Log general fertility rate	-0.090	0.269	-0.783**	0.347
Patients' characteristics				
Age	0.056***	0.001	0.055***	0.002
Insurable wage ($\div 10^2$)	-.0004***	0.00004	-.0004***	.0001
Aborigine	-0.069*	0.036	-0.375***	0.061
Previous c-section	7.601***	0.024	3.215***	0.033
Fetal distress	5.617***	0.027	1.487***	0.069
Dystocia	6.598***	0.019	2.735***	0.030
Breech	1.555***	0.039	0.400***	0.064
Other complications	4.417***	0.017	1.090***	0.035
Hospitals' characteristics				
Private non-profit	-0.538***	0.021	0.195***	0.031
Proprietary	0.150***	0.028	1.175***	0.040
Medical Center	0.156***	0.044	0.582***	0.059
Regional Hospital	-0.408***	0.031	0.123**	0.042
District Hospital	-0.158***	0.020	0.470***	0.023
Teaching Hospital	0.132***	0.027	0.081**	0.034
Bed size ($\div 10^2$)	-0.028***	0.002	-.0002	0.002
Ob/gyn characteristics				
Ob/gyn age	-0.005	0.004	-0.014*	0.006
Ob/gyn gender	0.001	0.024	0.125***	0.034
Constant	-4.921***	1.053	-2.314*	1.362
Log likelihood	-195,326.25			

Notes: The model also includes a full set of time and regional dummies. $N = 854{,}820$.
*Statistically significant at the 10% level. **Statistically significant at the 5% level.
***Statistically significant at the 1% level.

LR test (H_0: all $\mu_i = 0$): $LR = 2\left[\ln L(\hat{\theta}_u) - \ln L(\tilde{\theta}_r)\right] = 2\left[(-195{,}326.25) - (-199{,}467.89)\right] = 8283.28$

Table 27. Discrete Factor Model with Two Points of Support for Equation (5)

	C-section		C-section on maternal request	
Variables	Coef.	Robust Std. Err.	Coef.	Robust Std. Err.
Main explanatory variable				
Log ob/gyn per 100 births	-0.0001	0.091	0.791***	0.128
Patients' characteristics				
Age	0.057***	0.001	0.055***	0.002
Insurable wage ($\div 10^2$)	-0.0004***	0.00004	-0.0004***	0.0001
Aborigine	-0.069***	0.036	-0.375***	0.062
Previous c-section	7.601***	0.024	3.214***	0.033
Fetal distress	5.617***	0.027	1.488***	0.069
Dystocia	6.598***	0.019	2.735***	0.030
Breech	1.555***	0.039	0.400***	0.064
Other complications	4.417***	0.017	1.090***	0.035
Hospitals' characteristics				
Private non-profit	-0.538***	0.021	0.197***	0.030
Proprietary	0.150***	0.028	1.178***	0.040
Medical Center	0.156***	0.044	0.579***	0.058
Regional Hospital	-0.409***	0.031	0.123**	0.042
District Hospital	-0.158***	0.020	0.469***	0.023
Teaching Hospital	0.132***	0.027	0.084**	0.034
Bed size ($\div 10^2$)	-0.028***	0.002	-0.0004	0.002
Ob/gyn characteristics				
Ob/gyn age	-0.005	0.004	-0.014**	0.006
Ob/gyn gender	0.001	0.024	0.125***	0.034
Constant	-5.268***	0.154	-5.140***	0.233
Log likelihood	-195,308.91			

Notes: The model also includes a full set of time and regional dummies. $N = 854{,}820$.
**Statistically significant at the 5% level. ***Statistically significant at the 1% level.

LR test (H_0: all $\mu_i = 0$): $LR = 2\left[\ln L(\hat{\theta}_u) - \ln L(\tilde{\theta}_r)\right] = 2[(-195{,}308.91) - (-195{,}381.97)] = 146.12$

Table 28. Discrete Factor Model with Two Points of Support for Equation (3)

	Specification 1 (Comparison group: female physicians and female relatives of physicians; Treatment group: other women)		Specification 2 (Comparison group: high socioeconomic status women; Treatment group: low socioeconomic status women)	
Variables	Coef.	Robust Std. Err.	Coef.	Robust Std. Err.
Log general fertility rate	-0.275**	0.111	-0.050	0.270
Log general fertility rate × Information	-0.001	0.134	0.423**	0.157
Information	-0.097	0.490	-1.737**	0.592
Patients' characteristics				
Age	0.027***	0.001	0.027***	0.001
Insurable wage ($\div 10^2$)	-0.0002***	0.00002	0.0003	0.0002
Aborigine	-0.069***	0.016	-0.153***	0.027
Previous c-section	3.563***	0.009	3.516***	0.023
Fetal distress	2.558***	0.013	2.554***	0.032
Dystocia	3.122***	0.008	3.081***	0.020
Breech	0.665***	0.016	0.572***	0.036
Other complications	1.852***	0.008	1.869***	0.019
Hospitals' characteristics				
Private non-profit	-0.155***	0.009	-0.187***	0.021
Proprietary	0.214***	0.011	0.201***	0.027
Medical center	0.128***	0.018	0.190***	0.044
Regional Hospital	-0.112***	0.013	-0.048	0.030
District Hospital	0.045***	0.008	0.101***	0.017
Teaching Hospital	0.066***	0.011	0.045*	0.025
Bed size ($\div 10^2$)	-0.007***	0.001	-0.007***	0.002
Ob/gyn characteristics				
Ob/gyn age	-0.002	0.002	0.002	0.003
Ob/gyn gender	0.020**	0.010	0.065**	0.027
Constant	-1.366**	0.435	-2.308**	1.053
Log likelihood	-160,195.2		-30,188.225	

Notes: The models also include a full set of time and regional dummies. *N*= 854,820 for speciation1 and 148,908 for specification 2. *Statistically significant at the 10% level. **Statistically significant at the 5% level. ***Statistically significant at the 1% level.

LR test (H_0: all $\mu_i = 0$) for specification 1:

$$LR = 2\left[\ln L\left(\hat{\theta}_u\right) - \ln L\left(\tilde{\theta}_r\right)\right] = 2\left[\left(-160.195.2\right) - \left(-199{,}462.47\right)\right] = 76{,}534.54$$

LR test (H_0: all $\mu_i = 0$) for specification 2:

$$LR = 2\left[\ln L\left(\hat{\theta}_u\right) - \ln L\left(\tilde{\theta}_r\right)\right] = 2\left[\left(-30{,}188.225\right) - \left(-37{,}811.01\right)\right] = 15245.57$$

Table 29. Discrete Factor Model with Two Points of Support for Equation (4)

Variables	Specification 1 (Control group: female physicians and female relatives of physicians; Treatment group: other women) Coef.	Robust Std. Err.	Specification 2 (Control group: high socioeconomic status women; Treatment group: low socioeconomic status women) Coef.	Robust Std. Err.
Log ob/gyn per 100 births	0.174***	0.038	0.339***	0.090
Log ob/gyn per 100 births $\times$ Information	-0.008	0.126	-0.304**	0.146
Information	-0.103**	0.051	-0.293**	0.095
Patients' characteristics				
Age	0.026***	0.001	0.027***	0.001
Insurable wage ($\div 10^2$)	-.0002***	0.00001	0.0003	0.0002
Aborigine	-0.069***	0.016	-0.152***	.027
Previous c-section	3.563***	0.009	3.517***	.023
Fetal distress	2.559***	0.014	2.555***	0.032
Dystocia	3.123***	0.008	3.081***	0.020
Breech	0.665***	0.016	0.573***	0.036
Other complications	1.851***	0.008	1.869***	0.019
Hospitals' characteristics				
Private non-profit	-0.155***	0.008	-0.186***	0.021
Proprietary	0.214***	0.011	0.203***	0.027
Medical center	0.127***	0.018	0.188***	0.044
Regional Hospital	-0.113***	0.013	-0.050*	0.030
District Hospital	0.045***	0.008	0.100***	0.017
Teaching Hospital	0.068***	0.011	0.048*	0.025
Bed size ($\div 10^2$)	-0.007***	0.001	-0.007***	0.002
Ob/gyn characteristics				
Ob/gyn age	-0.002	0.002	0.002	0.003
Ob/gyn gender	0.020**	0.010	0.066**	0.027
Constant	-2.390***	0.067	-2.413***	0.145
Log likelihood	-160,188.210		-30,180.871	

Notes: The models also include a full set of time and regional dummies. *N*= 854,820 for speciation1 and 148,908 for specification 2. *Statistically significant at the 10% level. **Statistically significant at the 5% level. ***Statistically significant at the 1% level.
LR test (H_0: all $\mu_i = 0$) for specification 1:

$$LR = 2\left[\ln L\left(\hat{\theta}_u\right) - \ln L\left(\tilde{\theta}_r\right)\right] = -2\left[\left(-160{,}188.210\right) - \left(-160{,}195.980\right)\right] = 15.54$$

LR test (H_0: all $\mu_i = 0$) for specification 2:

$$LR = 2\left[\ln L\left(\hat{\theta}_u\right) - \ln L\left(\tilde{\theta}_r\right)\right] = 2\left[\left(-30{,}180.871\right) - \left(-30{,}235.683\right)\right] = 109.624$$

Table 30. Discrete Factor Model with Two Points of Support for Equation (3) (Base outcome: vaginal delivery; Control group: female physicians and female relatives of physicians; Treatment group: other women)

Variables	C-section Coef.	C-section Robust Std. Err.	C-section on maternal request Coef.	C-section on maternal request Robust Std. Err.
Log general fertility rate	-0.092	0.270	-0.783**	0.347
Log general fertility rate × Information	-0.095	0.317	-0.058	0.467
Information	0.085	1.157	0.097	1.690
Patients' characteristics				
Age	0.057***	0.001	0.055***	0.002
Insurable wage ($\div 10^2$)	-.0004***	.00004	-0.0003***	0.0001
Aborigine	-0.069*	0.036	-0.375***	0.062
Previous c-section	7.601***	0.023	3.215***	0.033
Fetal distress	5.616***	0.027	1.486***	0.068
Dystocia	6.599***	0.019	2.735***	0.030
Breech	1.556***	0.039	0.400***	0.063
Other complications	4.417***	0.017	1.090***	0.035
Hospitals' characteristics				
Private non-profit	-0.540***	0.021	0.194***	0.031
Proprietary	0.149***	0.028	1.175***	0.040
Medical Center	0.157***	0.044	0.582***	0.059
Regional Hospital	-0.408***	0.031	0.123**	0.042
District Hospital	-0.158***	0.020	0.470***	0.023
Teaching Hospital	0.132***	0.027	0.081**	0.034
Bed size ($\div 10^2$)	-0.028***	0.002	-0.0001	0.002
Ob/gyn characteristics				
Ob/gyn age	-0.0007	0.003	-0.012*	0.006
Ob/gyn gender	0.003	0.024	0.126***	0.034
Constant	-5.086	1.055	-2.391*	1.365
Log likelihood	-195,320.23			

Notes: The model also includes a full set of time and regional dummies. $N = 854{,}820$. **Statistically significant at the 5% level. ***Statistically significant at the 1% level.

LR test (H_0: all $\mu_i = 0$): $LR = 2\left[\ln L(\hat{\theta}_u) - \ln L(\tilde{\theta}_r)\right] = 2\left[(195{,}320.23) - (-199.462.47)\right] = 8284.48$

Table 31. Discrete Factor Model with Two Points of Support for Equation (4) (Base outcome: vaginal delivery; Comparison group: high socioeconomic status women; Treatment group: low socioeconomic status women)

	C-section		C-section on maternal request	
Variables	Coef.	Robust Std. Err.	Coef.	Robust Std. Err.
Log general fertility rate	0.967	0.671	-1.130	0.798
Log general fertility rate × Information	0.671*	0.387	1.347**	0.449
Information	-2.666*	1.454	-5.248**	1.670
Patients' characteristics				
Age	0.053***	0.003	0.059***	0.003
Insurable wage ($\div 10^2$)	0.0002	0.0001	0.001	0.001
Aborigine	-0.235***	0.064	-0.501***	0.101
Previous c-section	7.553***	0.057	3.053***	0.081
Fetal distress	5.657***	0.065	1.458***	0.157
Dystocia	6.551***	0.046	2.645***	0.069
Breech	1.352***	0.086	0.302**	0.139
Other complications	4.479***	0.041	0.948***	0.082
Hospitals' characteristics				
Private non-profit	-0.654***	0.053	0.138**	0.069
Proprietary	0.084	0.068	1.033***	0.087
Medical Center	0.335**	0.106	0.621***	0.130
Regional Hospital	-0.273***	0.073	0.269**	0.092
District Hospital	-0.086**	0.043	0.587***	0.048
Teaching Hospital	0.080	0.063	-0.006	0.073
Bed size ($\div 10^2$)	-0.029	0.004	0.002	0.005
Ob/gyn characteristics				
Ob/gyn age	0.005	0.008	0.003	0.011
Ob/gyn gender	0.095	0.067	0.148*	0.084
Constant	-9.212***	2.616	-1.366	3.118
Log likelihood	-37,124.929			

Notes: The model also includes a full set of time and regional dummies. N = 148,908.
**Statistically significant at the 5% level. ***Statistically significant at the 1% level.

LR test (H_0: all $\mu_i = 0$): $LR = 2\left[ln\,L\left(\hat{\theta}_u\right) - ln\,L\left(\tilde{\theta}_r\right)\right] = 2\left[\left(-37{,}124.929\right) - \left(-37{,}811\right)\right] = 1372.142$

Table 32. Discrete Factor Model with Two Points of Support for Equation (3) (Base outcome: vaginal delivery; Comparison group: female physicians and female relatives of physicians; Treatment group: other women)

	C-section		C-section on maternal request	
Variables	Coef.	Robust Std. Err.	Coef.	Robust Std. Err.
Log ob/gyn per 100 births	0.0002	0.091	0.791***	0.128
Log ob/gyn per 100 births $\times$ Information	0.133	0.295	-0.054	0.410
Information	-0.218*	0.118	-0.127	0.158
Patients' characteristics				
Age	0.056***	0.001	0.055***	0.002
Insurable wage ($\div 10^2$)	-.0004***	.00004	-.0003***	0.0001
Aborigine	-0.069*	0.036	-0.375***	0.061
Previous c-section	7.601***	0.023	3.215***	0.033
Fetal distress	5.616***	0.027	1.487***	0.069
Dystocia	6.599***	0.019	2.736***	0.030
Breech	1.555***	0.038	0.400***	0.064
Other complications	4.417***	0.017	1.090***	0.035
Hospitals' characteristics				
Private non-profit	-0.540***	0.021	0.196***	0.031
Proprietary	0.149***	0.028	1.177***	0.040
Medical Center	0.157***	0.044	0.580***	0.059
Regional Hospital	-0.408***	0.031	0.123**	0.042
District Hospital	-0.158***	0.020	0.469***	0.023
Teaching Hospital	0.133***	0.027	0.084**	0.034
Bed size ($\div 10^2$)	-0.028***	0.002	.00004	.002
Ob/gyn characteristics				
Ob/gyn age	-0.001	0.004	-0.012*	0.006
Ob/gyn gender	0.003	0.023	0.125***	0.033
Constant	-5.446***	0.162	-5.219***	0.249
Log likelihood	-195,302.82			

Notes: The model also includes a full set of time and regional dummies. $N = 854{,}820$.
**Statistically significant at the 5% level. ***Statistically significant at the 1% level.

LR test (H_0: all $\mu_i = 0$): $LR = 2\left[\ln L(\hat{\theta}_u) - \ln L(\tilde{\theta}_r)\right] = 2[(-195{,}302.82) - (197{,}158.7)] = 3711.76$

Table 33. Discrete Factor Model with Two Points of Support for Equation (4) (Base outcome: vaginal delivery; Comparison group: high socioeconomic status women; Treatment group: low socioeconomic status women)

	C-section		C-section on maternal request	
Variables	Coef.	Robust Std. Err.	Coef.	Robust Std. Err.
Log ob/gyn per 100 births	0.237	0.212	1.257***	0.290
Log ob/gyn per 100 births × Information	-0.492	0.234	-0.774**	0.252
Information	-0.421	0.358	-0.625*	0.364
Patients' characteristics				
Age	0.053***	0.003	0.058***	0.003
Insurable wage ($\div 10^2$)	0.0002	0.0005	0.001	0.001
Aborigine	-0.234***	0.064	-0.499***	0.102
Previous c-section	7.553***	0.058	3.056***	0.081
Fetal distress	5.657***	0.066	1.459***	0.156
Dystocia	6.552***	0.046	2.648***	0.069
Breech	1.354***	0.086	0.303**	0.139
Other complications	4.479***	0.040	0.949***	0.082
Hospitals' characteristics				
Private non-profit	-0.653***	0.053	0.138**	0.068
Proprietary	0.087	0.068	1.041***	0.087
Medical Center	0.332**	0.107	0.612***	0.129
Regional Hospital	-.276***	.073	0.263**	0.092
District Hospital	-.087**	.043	0.585***	0.048
Teaching Hospital	.084	.063	0.003	0.073
Bed size ($\div 10^2$)	-.030***	.004	0.003	0.005
Ob/gyn characteristics				
Ob/gyn age	0.005	0.008	0.003	0.011
Ob/gyn gender	0.097	0.066	0.148*	0.084
Constant	-5.409***	0.353	-5.396***	0.453
Log likelihood	-37,118.119			

Notes: The model also includes a full set of time and regional dummies. N =148,908.
**Statistically significant at the 5% level. ***Statistically significant at the 1% level.

LR test (H_0: all $\mu_i = 0$): $LR = -2\left[\ln L(\tilde{\theta}_r) - \ln L(\hat{\theta}_u)\right] = 2\left[(-37{,}118.119) - (-37{,}127.577)\right] = 18.916$

Table 34. First Difference Model for the Spillover Effect on Inpatient Tocolysis

	Specification 1 (Unit of observation: hospital/clinic)		Specification 2 (Unit of observation: ob/gyn)	
Variables	Coef.	Robust Std. Err.	Coef.	Robust Std. Err.
Δ *BITE*	-0.465***	0.103	-0.372***	0.033
Δ Proportion of patients with major disease card	39.597*	22.894	7.253**	3.457
Δ Mean of patient age	-0.890**	0.339	-0.052	0.080
Δ Attending ob/gyn number	0.001***	0.0004	0.003	0.004
Δ Mean of ob/gyn age	-0.611***	0.137	-0.059**	0.027
Δ Ob/gyn gender ratio	-2.370	5.305	-0.441	0.799
Δ Bed size	0.154***	0.005	0.005***	0.001
Δ Birth age women to population ratio	1.284	9.773	1.464	7.770
Δ Time	1.562	1.263	-0.377*	0.192
Constant	-0.599	0.489	-0.226	0.179
R-square	0.192		0.184	
Observations	2347		4464	

Notes: *Statistically significant at the 10% level. **Statistically significant at the 5% level. ***Statistically significant at the 1% level.

Table 35. Comparison of Coefficients on $\Delta BITE$ from the First Difference Models

Variables	Specification 1 (Unit of observation: hospital/clinic) Coef. on $\Delta BITE$	Specification 1 Robust Std. Err.	Specification 2 (Unit of observation: ob/gyn) Coef. on $\Delta BITE$	Specification 2 Robust Std. Err.
Accreditation status				
Medical center	-0.801	2.373	-0.860	2.292
Regional hospital	-0.388***	0.806	-0.661***	1.308
District hospital	-0.666***	0.157	-0.636***	1.091
Clinic	-0.069	0.601	-0.060	0.551
Teaching status				
Teaching	-0.821***	0.153	-0.852***	0.125
Non-teaching	-0.465*	0.281	-0.439**	0.209
Ownership				
Public	-0.867*	0.447	-0.827*	0.463
Private non-profit	-0.997**	0.383	-0.909***	0.153
Proprietary	-0.341*	0.176	-0.389*	0.212

Notes: *Statistically significant at the 10% level. **Statistically significant at the 5% level. ***Statistically significant at the 1% level.

Chapter 6: DISSCUSSIONS

6.1 Summary of Findings

This study investigates the effect of the shrinking fertility on the choice of delivery mode, exploiting the fact that the number of newborns dramatically declined from 1996 to 2004 in Taiwan. More specifically, because imperfect information has been recognized as a key feature of health care markets, does the rapidly declining fertility rate increase the use of c-sections, conditional on patients' professional background and presumed access to health information?

Findings from this study indicated that a one-percent decrease in the general fertility rate or one percent increase in the number of ob/gyn per 100 of births, will significantly lead to 0.102 and 0.064 percentage point increase in the probability of having c-section respectively, but these magnitudes are very small compared to previous reports. Further, these increases in c-sections were attributed to the increasing use of CDMR based on the results from the multinomial logit models.

The most interesting finding from this dissertation is that rapidly declining fertility increased the use of CDMR. Internationally or domestically, there are some evidence suggesting that CDMR is increasing, but it is unclear why (NIH, 2006). Any decision to deliver by CDMR should be guided by the best possible information regarding the potential health outcomes for both mother and baby. There are several explanations for the relationship between declining fertility increased the use of CDMR in Taiwan. First of all, age is an important and independent risk factor for c-sections. As women age, subfertility is more common, as is the use of reproductive technologies. Complications in labor may be associated with increasing maternal age and with the use of reproductive technologies. As increasing number of women choose to delay their first child in Taiwan, the relative benefits of CDMR may outweigh the risks. Second, culture beliefs and practices influence perceptions and desires regarding the labor and delivery. For example, Li (1995) contends that most Chinese people attempt calculate how to match his or her 'eight characters' (date and time of birth) with specific points occurring in the flow of cosmic time. Moreover, Lo (2003) analyzed Taiwanese data and reported that a significantly higher likelihood of c-sections on auspicious days among Chinese patients. In Chinese culture belief, babies born in such days will have health, dynastic nobility, and longevity. With the continued declining fertility rate, it is plausible that parents tend to request c-sections on auspicious days in order to pursue a bright future for their baby and avoid calamity to the baby and family, especially the low fertility will make parents value more on their baby. Third, a recent research by Wu (2000) indicated that some Chinese women believed that if their newborn was delivered by c-sections, the child will be more intelligent than if he or she had been delivered vaginally. A more recent study by Lee et al. (2001) on Hong Kong Chinese women showed that all these women thought that c-sections could help to ensure the baby's safety, to avoid personal risk, to avoid painful labor, and to avoid damage too the baby and loss of figure. Further, women did not want to expose their unborn babies to the risk of uncontrollable consequences during labor and vaginal birth. As a result of lower and lower fertility, women tend to have fewer children and put a high expectation on their children. Therefore, the need to produce a 'perfect baby' was obvious. Hence, CDMR may provide women a way to guarantee a better birth outcome, and the relationship between low fertility and high use of CDMR possibly reflects higher social value of newborns.

With regard to the role of the health information gap, the empirical results did not support the research hypothesis that ob/gyns compensate for income losses due to rapidly declining fertility by providing more medically-unnecessary c-sections instead of vaginal deliveries. On the other hand, the impact of declining fertility on likelihood of having CDMR did not vary across women's SES or occupational status. The empirical findings did not support the research that less medically-informed women prefer more c-sections than vaginal deliveries when the fertility rate goes down.

The test of spillover effects showed that income effect is significant in determining the volume increase in tocolytic hospitalization in response to the rapid decline in fertility. Because the empirical results do not support specific predictions of models (e.g., Gruber et al, 1996), this study raises more doubt as to whether inducement on c-sections is an important empirical phenomenon. Furthermore, this study also shows that there exist other income-recovery strategies for ob/gyns as McGuire (2001) suggested.

The main contribution of this dissertation is to add to the sparse literature by providing more empirical evidence as how fertility decline changes providers' and patients' choices of delivery modes. Although a significant amount of attention has been paid over the past decade to the consequences of financial pressures, the majority of them focus on the health care market in the U. S. that is difficult to generalize to health care systems in other countries. This dissertation based on the Taiwan experience should be more applicable to other developed and developing countries.

6.2 Conclusion and Policy Implications

Findings from this study raise some critical issues. First of all, it solved the mix of myth and reality driving maternal and ob/gyns' choices of delivery modes due to dramatically declining fertility. The rapidly declining fertility rates have evoked throughout many developed countries, and this study offered a precautionary note to those countries where the privatization of health care and its financing is ushering in ingenious ways of cost containment. On the other hand, these findings can readily generalize to many low- and middle- income countries. The disproportionately high c-section rates in Taiwan may hold major lessons for the many countries contemplating or having universal health insurance coverage with a similar mix of providers.

Because of the rare, exogenous occurrence of fertility decline in Taiwan and the use of detailed medical information and crucial demographic attributes of pregnant women (e.g. occupational status), this dissertation is able to avoid the endogeneity problem that has threatened the validity of many existing health economics studies on cesarean deliveries and to more accurately estimate physicians' ability to induce demand because of their expertise in medical knowledge. Results of this study, therefore, contribute to the international literature on demand inducement and provide policy recommendations with regard to physician behavior and practice. This dissertation further adds to the existing empirical literature of demand inducement by incorporating the role of health information gap. Nevertheless, given the existence of asymmetric information between providers and patients, it may be argued that physicians would more likely to induce; investigating how much physicians induce, and the impact of inducement, are perhaps more fruitful than investigating whether inducement exists per se (Yip, 1998).

From the policy point of view, results of the spillover effects from this study also raise concerns regarding the extent to reform payment scheme on deliveries. Several strategies have been adopted or proposed to reduce the rate of cesarean deliveries, including education and peer evaluation, external review, public dissemination of cesarean delivery rates, changes in physician payment, changes in hospital payment, and medical malpractice reform (Stafford, 1990). These strategies differ in their assumptions regarding their feasibility and the determinants of physicians' autonomy (Hsu, Lo, Chang, Chen, Yu, Huang, 2007). Because results from this study does not support the research hypothesis that ob/gyns would use more profitable c-sections to replace vaginal deliveries, the effects of reforms on payment schemes on the c-section rate remain an interesting question.

Furthermore, it is important to use appropriately documented data and to compare them with international data when monitoring local obstetric practices. The perception that the risks of c-sections are similar or lower than attempted vaginal birth after c-section (VBAC) and the shift away from vaginal breech deliveries may further contribute to societal acceptance of cesarean births. Such a shift in acceptance by patients and providers may lead to an increase in CDMR (NIH, 2006). It is accepted that trial of labor entails some maternal and fetal risk in women with a prior cesarean delivery, and obstetricians fear uterine rupture and its catastrophic consequences. Therefore, the women are usually not offered the option of VBAC because physicians are afraid of malpractice suits, and the women often refuse that option if it is offered to them because they are afraid of the pain and risk involved.

Moreover, painless labor is still not popular in Taiwan and is not covered by NHI, and this possibly explained the increase in CDMR rates in Taiwan. In the context of childbirth, risks and benefits of CDMR versus planned vaginal delivery must be individualized and based on a shared decision making process. After thorough discussion and review, CDMR may be a reasonable alternative to planned vaginal delivery. The foundation of the ethical relationship between a woman and her healthcare providers should be based on a respectful partnership that requires the exchange of accurate and complete information as well as effective communication.

Last but not least, policymakers should also be aware of the remarkable potential that decoupling physician reimbursement levels from the cost of the technology that is used may help to restrain the diffusions of procedures whose additional benefit is exceeded by their incremental cost. Countries with large or universally insured population should evaluate delivery profiles associated with the availability of health information, institutional size, and reimbursement policies.

6.3 Limitations

This dissertation has several limitations. First of all, it would be ideal to calculate the marginal effect of the interaction term “Log general fertility rate × Information” or “Log ob/gyn per 100 births × Information” from discrete factor model to take the individual heterogeneity into account. Because of the availability of statistical package and time limitation, this study used estimations without considering the existence of individual heterogeneity, and it is a more conservative approach. Based on this approach, insignificant marginal effect of the interaction terms does not necessarily mean zero effect of inducement.

Second, this study measures patients’ availability only by her occupational status and monthly insurable wage due to the limitation in NHIRD. Debates about the appropriate use, rates, and relative safety of c-sections are likely to continue. Using physicians and family members of physicians, or high socioeconomic women as a reference group may be reasonable in the short term, but is perhaps not good enough. A more careful analysis that combines the patients’ educational level may be necessary to evaluate the effect of declining fertility and the health information gap on the choice of delivery modes. Moreover, household income could be a more appropriate measure than monthly insurable wage to proxy women’s socioeconomic status, because by the later measure a housewife married to a rich lawyer will be categorized into low SES group.

Third, this study may suffer from certain inherent limitations from the use of administrative data containing limited diagnostic and clinical information. For example, information on some other important indications for c-section such as parity is not available. Chart reviews or birth certificates may be more informative in this regard. Data limitation also prevents investigation of the demand inducement on ob/gyn services other than obstetric deliveries and tocolytic hospitalization.

Fourth, the spillover effects in this study only focus on tocolytic hospitalization, however, compared with other ob/gyn services, advances in health technology for tocolytic treatment have been relatively slow in recent years. Thus, results of spillover effects may be different when applying the analysis to other ob/gyn services, particularly the ones experiencing substantial technological progress (e.g., artificial reproductive technology).

Fifth, this study followed Chou et al.'s study to exclude foreign mothers in the empirical analysis. Actually foreign mothers have lower c-section rates than Taiwanese mothers, but in NHIRD there is no perfect way to identify women with foreign nationality. In this study I used the length of patient ID in NHIRD to define foreign mothers, and it is not the most precise way because those IDs have been scrambled and the way to encrypt IDs was changed by BNHI for several times. Therefore, excluding foreign mothers may lead to biased conclusions and a possible way to solve this problem is to analyze the birth certificate data that contain the original IDs.

Finally and most importantly, the measure of income shock to providers is not perfect in this study. For example, in testing the spillover effects, the variable BITE constructed in this study is only an approximation. An ideal measure of the income effect is the share of an ob/gyn's total practice income (including both inpatient and outpatient revenues as well as services not covered by NHI) that is derived from delivery procedures, because in Taiwan the outpatient ambulatory care revenue is also a significant income for ob/gyn clinics and hospitals. Thus, ignoring the outpatient practice revenue may underestimate other possible income-recovery strategies. Further, more precise case-mix adjustment should be considered when comparing different providers' practice. This study only used the mean of patients' age and the proportion of patients with catastrophic disease card as simple adjustments for patient's disease severity. Future research should construct a severity index (could be measured by the mix of ICD-9-CM) for each provider to make their behaviors more comparable.

6.4 Directions for Future Research

There are several subjects of future work related to this study. First of all, as Gruber et al. (1996) pointed out, similar tests could be carried out for the adoption of other medical technologies in different time periods. Depending on the availability of data, future work could explore whether inducement and information on the aspects of the treatment regimen other than c-section or inpatient tocolysis, such as the diffusion of new medical procedures (e.g., laparoscopy) that are also reimbursed under NHI.

Second, efforts must continue to contain the rising trend of c-sections, and minimize the potentially inappropriate use of this procedure in the long run. How to make sufficient and reliable information available to pregnant women so that they can make informed decisions will be an important issue to Taiwan and other countries facing similar problems. Moreover, this study only provides quantitative evidence of the relationship between declining fertility and increasing CDMR. Qualitative methods may be more useful to investigate whether and to what extent CDMR are made (Weaver et al., 2007), especially the roles of non-clinical and psychological factors.

Third, current NHIRD data on nurses have not been updated regularly, and it makes the use of female nurses as a comparison group (i.e., medically informed individuals) inappropriate. In fact, other medical professionals such as female dentists and should also be included in the comparison group of information gap, because they also have professional knowledge of the health risks and benefits associated with different delivery modes. If more updated information of female nurses and dentists is available, then future studies could consider using female nurses and dentists as a comparison group to investigate the role of health information gap on the use of c-sections. Moreover, it will substantially increase the sample size of the comparison group and yield a more reliable analysis.

Fourth, because all IDs in NHIRD have been scrambled by BNHI, it is difficult to link NHIRD with other datasets. If researchers can merge birth certificate data and insurance claims data when the individual IDs in both dataset can be merged becomes feasible in the future (depending on the collaboration of BNHI and DOH), then it may offer more opportunities to advance research agenda. The birth certificate data have information on birth parity, mother's and father's educational level, and infant's health outcomes (e.g., birthweight). While the insurance claims data have rich information on medical history, health care expenditures, and providers' characteristics. To date, there is no conclusive data on the long-term impact on women's physical and psychological health and life satisfaction following c-section compared with vaginal delivery. Such study could also provide some evidence on the welfare implication associated with different delivery modes.

Fifth, for the use of medically-unnecessary c-sections, provider fee policy remains the tool of choice for policy makers in trying to rein such costs. Since 2006, BNHI has inaugurated a new policy that equalized the reimbursements for c-sections and vaginal deliveries, and this policy imposes a relative increase of vaginal delivery fees of 80%. This policy change could serve as a natural experiment to examine whether changing payment scheme for delivery modes under a single-payer system would lower the intensity of obstetric interventions of childbirth.

Finally, with the continued declining trend in fertility in Taiwan, there must be some changes in ob/gyn market structure and providers' behavior and practice could also be affected. The use of Herfindahl-Hirschman index (HHI) to determine the competitive features of ob/gyn markets could be a better way to examine how declining fertility affects providers' behavior and practice as well as patients' health outcomes. The HHI for a market is the sum of the squared market shares of all of the hospitals competing within the market, and a more flexible method such as "variable radius" HHI that allow each provider to a flexible and specific distance radius with controlling for provider fixed effects would be preferred to be used in future research as a better control of the dynamics of ob/gyn markets.

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