Journal of Health Economics 66 (2019) 1–17

Contents lists available at ScienceDirect

Journal of Health Economics

journal homepage: www.elsevier.com/locate/econbase

# Uterus at a price: Disability insurance and hysterectomy

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ARTICLE INFO

*Article history:*
Received 10 September 2018
Received in revised form 5 April 2019
Accepted 8 April 2019
Available online 23 April 2019

*JEL classification:*
I00
I10
I12
I18

*Keywords:*
Disability insurance
Moral hazard
Hysterectomy
Oophorectomy

ABSTRACT

Taiwanese Labor, Government Employee, and Farmer Insurance programs provide 5 to 6 months of salary to enrollees who undergo hysterectomies or oophorectomies before their 45th birthday. These programs create incentives for more and earlier treatments, referred to as inducement and timing effects. Using National Health Insurance data between 1997 and 2011, we estimate these effects on surgery hazards by difference-in-difference and bunching-smoothing polynomial methods. For Government Employee and Labor Insurance, inducement is 11–12% of all hysterectomies, and timing 20% of inducement. For oophorectomies, both effects are insignificant. Enrollees' behaviors are consistent with rational choices. Each surgery qualifies an enrollee for the same benefit, but oophorectomy has more adverse health consequences than hysterectomy. Induced hysterectomies increase benefit payments and surgical costs, at about the cost of a mammogram and 5 pap smears per enrollee.



## 1. Introduction

We study the effect of disability insurance on the moral hazard of health care use. Disability insurance compensates enrollees for the loss of physical and mental capacities that adversely affect labor market potentials (Staubli, 2011; Maestas et al., 2013; French and Song, 2014). Taiwan adopts comprehensive employment-based mandatory disability programs. However, the Taiwanese programs include an uncommon coverage for women's infertility due to i) hysterectomy (surgical uterus removal), ii) oophorectomy (surgical ovaries removal), and iii) radio-chemo therapy. Enrollees are entitled to a cash benefit, equal to about 5 to 6 months of salaries when they undergo these treatments, but the coverage ends at enrollees' 45th birthday.

Organ dismemberment insurance policies are common. However, we are unaware of evidence that these policies have "caused" enrollees to lose a thumb, a toe, an eye, or get an eardrum perforated. Compensations are almost never high enough compared to the loss disutility. However, the unique Taiwanese programs afford us the rare research opportunity to examine if disability insurance has caused enrollees to have organ-removal surgeries.[1] Clearly, hysterectomies and oophorectomies are performed based on illness indications, but may still be performed when severity may not justify surgery. Does disability insurance lead to excessive treatments that would not have been performed otherwise: an inducement effect? Does disability insurance lead to treatments being expedited to before the 45th birthday: a timing effect?

Only hysterectomy exhibits significant inducement and timing effects; oophorectomy does not. About 11-12% of hysterectomies in our sample can be attributed to the inducement effect, and under 20% of induced surgeries can be attributed to the timing effect. These are striking results. First, the disability coverage offers the same benefits due to hysterectomy or oophorectomy. However, oophorectomy has far more serious adverse health consequences than hysterectomy (more thorough discussions in Section 2.1). If an enrollee chose to undergo one procedure solely for the disability benefit, the preferred procedure would be the less unpleasant hysterectomy, not oophorectomy. Of course, surgeries should be

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[1] In Japan, benefits due to infertility suffered at work are covered, but the Taiwan programs are universal, not limited to injury at work.

https://doi.org/10.1016/j.jhealeco.2019.04.001
0167-6296/

justified by illness severity. Inducements separate out unjustified surgeries. And we have only found significant inducement with hysterectomy. The evidence is consistent with optimizing behavior—even when the decision involves a surgery to remove a major organ.

Second, the disability insurance implementation turns out to be very costly. The Taiwanese already have national health insurance, so surgery inducement due to disability insurance occurs in addition to moral hazard due to health insurance. Linking a disability to a surgical procedure creates double moral hazard, one in the disability claim, and another in health care use. Our results serve as a warning against using a medical treatment as a qualification for disability benefits.

Third, this study sheds some light on monetary incentives and human organs in general. Our evidence suggests that individuals make consistent choices. The lack of inducement and timing effects in oophorectomy perhaps is the strongest evidence that for a given price of an organ, individuals reject the offer if and only if the disutility is sufficiently high. We have also found that, in the income-stratified samples, induced-hysterectomy rates are increasing in the benefit levels.

We estimate the inducement and timing effects by difference-in-difference and bunching-smoothing polynomial methods. The difference-in-difference design is based on the comparison of enrollees in three disability insurance programs and those uninsured between 1997 and 2011. The three programs are Labor Insurance, Government Employee Insurance, and Farmer Insurance. The uninsured are mostly women who are inactive in the labor force. Our data are from Taiwan's National Health Insurance. In addition, we use the Survey of Family Income and Expenditure (SFIE) to control for socio-demographic and economic factors.

We follow women for 11 years, between their 39th and 50th birthdays. In the main analysis, we include only enrollees who have not changed their insurance programs in the sample years. We then group enrollees by their birth cohorts and insurance programs, and calculate the hysterectomy and oophorectomy hazards for quarters (a 91-day period) before and after the 45th birthday. For each birth cohort, we also use the average numbers of children and sons, marital status, and household income as covariates.

Our difference-in-difference design is unconventional because there is not a policy change, so no before-and-after regimes. However, the insured lose the infertility disability benefit at age 45. Obviously, the benefit expiration is irrelevant to the uninsured. Our assumption is that the disability insurance effect is muted when the enrollees are young. This is because most uterine problems occur past late thirties, so surgeries to qualify for benefits are infeasible until enrollees become older. To operationalize our empirical strategy, we let the disability benefit become a relevant policy intervention when enrollees turn 40 years old. We have chosen to be cautious: if the deadline had become relevant before the 40th birthday, our assumption would have yielded difference estimates smaller than the actual differences.

We examine quarter-by-quarter hazard differences between the insured and uninsured, for 20 quarters before and after expiration. For hysterectomy, Labor Insurance and Government Employee Insurance enrollees' hazards begin to rise rapidly 8 quarters before expiration, but drop rapidly for 2 quarters after. Enrollees in Farmer Insurance show similar but less pronounced hazard changes. For oophorectomy, these rapid changes are absent in all insurance programs.

From the estimates we calculate inducement and timing effects. The inducement effect is the total number of insured enrollees' extra surgeries between their 40th and 50th birthdays compared to the uninsured. The timing effect consists of the total number of surgeries that the insured would have undergone after the 45th birthday compared to the uninsured. In our sample, Labor Insurance enrollees have a total of 43,845 hysterectomies, and the inducement effect is 5,076 hysterectomies, or about 11.6%. For Government Employee Insurance, the total is 7,262, and the inducement effect is 789, or 10.9%; the timing effect is about 20% of inducement. For Farmer Insurance, the total is 9,100, and the inducement effect is 347, or 3.8%. No inducement or timing effects have been found for oophorectomy.

We also use a bunching-smoothing polynomial estimation (see e.g. Saez, 2010; Chetty et al., 2011), which assumes that surgeries do not happen abruptly over time. We use hazards in benefit quarters far from the 45th birthday to fit a polynomial. Then we use the fitted polynomial to predict the hazards in benefit quarters near the 45th birthday. Any discrepancy between predicted and actual hazards is attributed to disability insurance. Inducement and timing effects are defined analogously. Bunching-smoothing polynomial estimation yields inducement and timing effects similar to those in the difference-in-difference method.

As a falsification check, we estimate inducement and timing effects of partial oophorectomy (the removal of one ovary), and myomectomy (the removal of the inner lining of the uterus). These procedures are used to alleviate problems in the female reproductive system, but do not qualify for the infertility disability benefit. We have found no inducement or timing effects for these procedures.

We also consider a number of robustness issues and policy implications. Our primary sample consists of female enrollees who have not switched insurance programs. For a larger sample, we include those who have switched between programs. Next, enrollees in the main sample are women aged between 39 and 49 years old during the period 1997 to 2011. Early cohorts are subject to left censoring; late cohorts, right censoring. For a smaller sample, we only use data from those with uncensored medical records in the sample period. We show that our results are robust.

We estimate benefit payments and surgery costs induced by disability insurance. We estimate that on average, the increase in benefit payment is about NT$1,410 or US$47 (the exchange rate is US$1 for NT$30 in 2015) per enrollee, and the hysterectomy cost is about NT$400 per enrollee. For comparison, the reimbursement rate for mammogram and pap smear are, respectively, NT$1,245 and NT$80. Hence, the inducement cost is more than enough to pay for 1 mammogram and 5 pap smears for each enrollee.

Age-based insurance benefits are quite common. Medicare in the United States provides health insurance to individuals above 65. Research has shown that patients delay treatment or surgeries until they become eligible for Medicare (see McWilliams et al., 2003, 2007; Card et al., 2008, 2009). The spike in hysterectomies for insured Taiwanese just before age 45 is consistent with results in the existing literature, but oophorectomies do not exhibit such a spike.

Our empirical strategies use a modified difference-in-difference regression and a bunching-smoothing polynomial estimation. Difference-in-difference regression is standard for policy evaluations (see Imbens and Wooldridge, 2009). Here, we study quarter-by-quarter policy effects, as in Chandra et al. (2010). Autor et al. (2007) use a similar year-by-year difference-in-difference model to understand how mandated employment protections reduce productive efficiency. Hoynes et al. (2015) also use the same method to study how earned income tax credit influences infant health outcomes.

Our bunching-smoothing polynomial estimation is similar to the method for assessing policy discontinuity effects. For example, taxes can be discontinuously related to reported incomes (Saez, 2010; Chetty et al., 2011; Kleven and Waseem, 2013), tax reliefs may be available to couples only if marriages or child births happen before a deadline (Persson, 2015), or students' test scores bump up over key grade cutoffs in nationwide math tests, and teachers use discretion in their grading to achieve the discrete jumps (Diamond and Persson, 2016). We use the standard assumption that, absent the policy, the variable of interest should change smoothly. Our method is more closely related to Diamond and Persson (2016) in that we use minimum mean-squared errors to determine the manipulated regions and then estimate the counterfactual surgery polynomials. In addition, we are interested in assessing the enrollees' overall responses and their timing, so implementing a regression discontinuity design is inappropriate.

We present the study background in Section 2. Section 3 describes the data, the samples of enrollees, and sample statistics. In Section 4, we present the two econometric methods. Section 4.1 is on the difference-in-difference method, and Section 4.2 is on the bunching-smoothing polynomial method. Two subsections in Section 5 present estimation results. In Section 6, we consider bigger and smaller samples according to program-switching and censoring criteria. Next, we stratify Labor Insurance enrollees according to five benefit levels, to examine inducement variations. Finally, we present inducement social cost estimates. We draw some conclusions in Section 7. Appendix A contains tables of estimation results; Appendix B contains plots of actual and counterfactual hazard distributions from the bunching-smoothing polynomial estimation.

## 2. Background

### 2.1. Hysterectomy and oophorectomy

Hysterectomy is the surgical removal of a woman's uterus, the organ that holds the fetus. This is the second most common elective surgery among women, after cesarean section for childbirth. Hysterectomies are performed mainly for uterine fibroids and malignant tumors, common indications being heavy bleeding, and serious pain (Department of Health and Human Services, 2011).[2] Myomectomy (the surgical removal of some uterine lining), endometrial ablation (surgical removal of endometrium), pain medication, synthetic steroid hormones, and pelvic floor exercises are less invasive alternatives. Usually performed by an obstetrician-gynecologist, hysterectomy may be abdominal, vaginal, or laparoscopic. The surgery has a mortality rate below 0.05%. Complications, such as bleeding and dysfunctional uterine parity, are also rare (McPherson et al., 2004). The length of hospital stay for the procedure ranges from 3 to 5 days.

Hysterectomy incidence rises steadily from ages 30 to 39, peaking between 45 and 49, and declining quickly thereafter (Huang et al., 2016; McPherson et al., 2013). Incidence rates, measured as hysterectomy surgeries in a year per unit of population, vary across countries. According to OECD Statistics, in 2012, the average hysterectomy incidence rate was 179 per 100,000 women, but it was 325 in United States, 318 in Germany, and only 49 in Denmark (Huang et al., 2016; McPherson et al., 2013).

For Asian countries, the incidence rate for South Korea was 198 in 2012 (OECD Health Statistics, 2016). In Taiwan, with a population of 23 million, an average of 23,000 hysterectomies are performed each year. From 1999 to 2005, Taiwanese hysterectomy incidence rates varied between 243 and 197 (Huang et al., 2016). Based on National Health Insurance Data, it is estimated in 2008 that Taiwanese women have a life time hysterectomy probability of 15.2%; when Taiwanese women become 55 years old, about 11.1% would have undergone hysterectomies (Huang et al., 2016).

Oophorectomy is the surgical removal of one or both ovaries, ovarian cancer being a primary indication, and is commonly done by abdominal laparoscopy. Oophorectomy causes the spontaneous menopause onset. Most patients are advised to start hormonal replacement post operation. The health risks associated with total oophorectomy are serious—women who have had oophorectomies before 45 years old have a mortality risk 170% higher than those who have not (Parker et al., 2005). Oophorectomy incidence is low. Between 1997 and 2011 less than 2,300 of Taiwanese women between 40 and 50 years old underwent total oophorectomies, but the corresponding number was more than 10,000 for hysterectomies.

### 2.2. Disability insurance

In Taiwan, three mandatory social insurance programs provide disability insurance to the working population. Enrollment is only for the individual, without any family coverage. Labor Insurance is the largest program, covering nearly 9 million workers in the private sector in 2012. When it was established in 1956, it provided only health insurance, but by 1978 insured enrollees had coverage for disability, maternity, occupational injuries, unemployment, pension, and death; fertility coverage likely started decades earlier than our sample period of 1997-2011. After 1995, Taiwan's National Health Insurance replaced health insurance in Labor Insurance. The second largest social insurance program is Farmer Insurance. In 2012, this program covered 1.5 million farmers. Government Employee Insurance, the third program, is for public employees and teachers in public and private schools and colleges. In 2012, Government Employee Insurance covered about 0.6 million lives. Similar to Labor Insurance, Farmer Insurance and Government Employee Insurance provide a portfolio of benefits, which include disability insurance.[3]

A woman is eligible for this disability benefit if, due to illnesses, she undergoes hysterectomy, total oophorectomy, and radio-chemo therapy on ovaries before turning 45 years old. Taiwan's National Health Insurance covers most in-patient expenses, so the disability benefit is additional to health expense coverage.[4]

The disability benefits are calculated according to an enrollee's "insurance salary." For Government Employee Insurance, in 2013 the insurance salary is the lower of an enrollee's base monthly salary and NT$53,900. However, the base salary does not include stipends (e.g. research stipends for college teachers), so an enrollee in Government Employee Insurance typically has earnings higher than the base salary.[5] For Labor Insurance, in 2013, the insurance salary is defined to be the lower of an enrollee's actual monthly salary and NT$43,900. For Farmer Insurance, the insurance salary is fixed at NT$10,200 per month. Disability benefits are 6 months of insurance salary in Government Employee Insurance, and 5.3 months in both Labor Insurance and Farmer Insurance.

What can be the rationale behind the Taiwanese infertility coverage? In Chinese culture, children often take care of their parents, so infertility can be likened to a loss of future resources. Besides, infertility likely adversely affects a woman's prospect in the marriage "market." Both reasons can be the motivation for the infertility benefit.

Recipients of disability benefits are mostly patients who have undergone hysterectomy. Complete oophorectomy is less common, and there are so few radio-chemo therapy cases that we have ignored it. Our research tests if disability insurance has caused

[2] In a random sample of 658 Taiwanese women, the most common indication for hysterectomy was uterine fibroids (at 46.2%), followed by malignancy and premalignancy (at 22.2%) (Wu et al., 2005).

[3] Government Employee Insurance does not provide unemployment insurance. Farmer Insurance does not offer unemployment insurance or pension scheme.

[4] The co-insurance rate of inpatient services for Taiwan's National Health Insurance is 10%, with spending caps. In 2011, the caps per admission and per year were NT$28,000 and NT$47,000 respectively.

[5] For instance, the base salary and research stipend for an assistant professor in 2012 was approximately the same, at NT$41,755 and NT$39,555, respectively.

**Table 1**
Insurance program changes before hysterectomy

| | Insurance program in the year of hysterectomy | | | | | |
|---|---|---|---|---|---|---|
| Insurance program in the year before hysterectomy | (1) Labor Insurance | (2) Government Employee Insurance | (3) Farmer Insurance | (4) Trade Union | (5) Uninsured | Total |
| Percentage changes | | | | | | |
| (1) Labor Insurance | 91.94% | 0.03% | 0.18% | 3.54% | 4.30% | 100% |
| (2) Government Employee Insurance | 0.95% | 97.55% | 0.06% | 0.19% | 1.26% | 100% |
| (3) Farmer Insurance | 1.66% | 0.00% | 96.54% | 0.79% | 1.01% | 100% |
| (4) Trade Union | 2.19% | 0.01% | 0.03% | 96.93% | 0.83% | 100% |
| (5) Uninsured | 5.81% | 0.10% | 0.64% | 6.84% | 86.61% | 100% |
| Enrollees with hysterectomiesin different program (obs.) | 67,719 | 8,920 | 11,693 | 53,911 | 37,748 | 179,991 |

more surgeries. Hysterectomy carries less disutility than oophorectomy, so we expect any effect would be stronger for hysterectomy. As a falsification check, we will study partial oophorectomy and myomectomy, which do not qualify for disability benefit.

## 3. Data and samples

### 3.1. Data

Our sample period spans 15 years, from 1997 to 2011. Subjects are females born between 1948 and 1972. We study their experiences between their 39th and 50th birthdays during the sample period. We use three data sets. The first is the set of hospital claims from Taiwan National Health Insurance between 1997 and 2011. The claims data include all inpatient admissions. Each claim includes a patient's demographics (gender and date of birth), admission date, disease diagnoses, medical reimbursement, and any surgery performed during the admission. Each claim also has scrambled unique identifiers for patients, doctors and hospitals. We use the surgical-procedure information to identify those who have undergone hysterectomy, oophorectomy, myomectomy, or partial oophorectomy. We use a patient's date of birth and admission date to check whether hysterectomy and oophorectomy have been performed before the 45th birthday. The infertility benefit is paid once even if both hysterectomy and oophorectomy are performed.

Our second data set is the National Health Insurance enrollment file. The file contains the last entry of each enrollee's insurance program and disability insurance salary at the end of a calendar year. We first use an enrollee's insurance type to infer the disability insurance salary. National Health Insurance started in 1994 by merging many private and public insurance programs, and its enrollment file has continued to track enrollees' other social insurance modules. From the enrollment file, we classify subjects' disability insurance status into four groups: Government Employee Insurance, Labor Insurance, Farmer Insurance, and otherwise uninsured.[6]

Next, we obtain enrollees' disability benefit information in the National Health Insurance enrollment file. National Health Insurance premium is set at a percent of an enrollee's monthly salary up to NT$188,000, which is much higher than the salary caps for disability benefits. Therefore, from the National Health Insurance premium, we can infer an enrollee's salary, and, in turn, the benefits. This inference is exact for enrollees in Labor Insurance. Government Employee Insurance uses the base salary, a fraction of the total salary, for benefit calculation, so the enrollee's salary in the National Health Insurance enrollment file will over-estimate the benefit. (For this reason, our analysis in Section 6.2 will be based on Labor Insurance enrollees.) The disability benefit in Farmer Insurance is fixed, so we do not need to use salary information from National Health Insurance.

Our third data set is from the Survey of Family Income and Expenditure (SFIE), conducted by Taiwan's Directorate General of Budget, Accounting and Statistics. Each year the survey randomly samples 13,000-16,000 households (or about 52,000–68,000 individuals) and collects information on socio-demographic characteristics of each member of the sampled households. For our sample period 1997-2011, we obtain the following information about female respondents in the 39-49 age group: highest education level, marital status, number of children by gender, monthly household earnings, and disability insurance type. We then use the disability insurance type to merge with the enrollment files to control for enrolled population demographics.

### 3.2. Samples

We define our sample in the following way. First, we follow enrollees' decisions for six years before, and five years after, the 45th birthday. Next, we impose a number of restrictions. We remove those in Labor Insurance whose enrollments were through trade union memberships, because these enrollees could misreport self-employment income.[7] We also delete a small number of enrollees who were in military or welfare programs, because their access to health services might be different.

Furthermore, enrollees may change social insurance programs through employment changes because of benefit differences. The strategic switch between disability insurance programs creates a selection problem. For the main analysis we use a sample of enrollees who have never changed their insurance status within the sample period. We call this the nonswitching sample. The general sample refers to all female enrollees regardless of any change in insurance programs during the sample period.

Table 1 illustrates the extent of strategic insurance program switches. The table includes insured enrollees and those covered by trade union memberships, and the uninsured who have had hysterectomies during the sample period. There are almost 180,000 hysterectomies. For each enrollee, we note her insurance program in the year in which hysterectomy is undertaken, and her insurance program the year before. Consider the row under Labor Insurance in Table 1. The number 91.94% is the fraction of all Labor Insurance enrollees who have undergone hysterectomies under the same program. Only 0.03% of Labor Insurance enrollees have changed to Government Employee Insurance when they have had hysterec-

[6] Up until 2002, the National Health Insurance enrollment file contained full insurance enrollment records. From 2003 onward, the enrollment file only contained enrollees' last disability insurance record in a calendar year; it no longer tracks an enrollee's disability insurance program changes during the year. For consistency, we use the last disability insurance record even for years before 2003.

[7] Labor law in Taiwan requires private companies with five or more employees to purchase Labor Insurance for all employees. Self-employed workers or those who work in firms with fewer than 5 employees are not required to participate, or they can participate through trade unions. Salaries of these workers are often unstable or under-reported. For the comparison between insured salary and earned salary in various insurance groups, see Lien (2011).

**Table 2**
Sample censoring and balance.

| Cohorts | Age at 1997 | Age at 2011 | | Years in sample | Data at 45th birthday |
|---|---|---|---|---|---|
| 1948 | 49 | 63 | Left-censored | 1 | no |
| . | . | . | . | . | . |
| 1952 | 45 | 59 | Left-censored | 5 | no |
| 1953 | 44 | 58 | Left-censored | 6 | yes |
| . | . | . | . | . | . |
| 1956 | 41 | 55 | Left-censored | 9 | yes |
| 1957 | 40 | 54 | Left-censored | 10 | yes |
| 1958 | 39 | 53 | Balanced | 11 | yes |
| 1959 | 38 | 52 | Balanced | 11 | yes |
| 1960 | 37 | 51 | Balanced | 11 | yes |
| 1961 | 36 | 50 | Balanced | 11 | yes |
| 1962 | 35 | 49 | Balanced | 11 | yes |
| 1963 | 34 | 48 | Right-censored | 10 | yes |
| 1964 | 33 | 47 | Right-censored | 9 | yes |
| . | . | . | . | . | . |
| 1966 | 31 | 45 | Right-censored | 6 | yes |
| 1967 | 30 | 44 | Right-censored | 5 | no |
| . | . | . | . | . | . |
| 1972 | 25 | 39 | Right-censored | 1 | no |

tomies the following year; 0.18% of Labor Insurance enrollees have changed to Farmer Insurance, etc.

Table 1 shows that insured enrollees overwhelmingly have had the same insurance program as the year before when they undergo hysterectomies. More than 90% of those in Labor Insurance have not changed the program from the year before hysterectomies; the corresponding numbers for Government Employee Insurance and Farmer Insurance are even higher, at 98 and 97%. The lower corresponding percentage of just below 87% for the uninsured likely indicates some strategic changes. Almost 6% of the uninsured have become insured under Labor Insurance when they have hysterectomies, and almost 7% have become insured through trade union memberships. We use the nonswitching sample for the main analysis, and the general sample for robustness check and social cost calculations.

Our data period is the 15 years between 1997 and 2011. We include female enrollees born between 1948 and 1972 for their experiences between their 39 and 49 birthdays, when these experiences happen between 1997 and 2011. Table 2 presents the birth cohorts and their corresponding ages in 1997 and 2011. The oldest cohort, those born in 1948, would be 49 years old in 1997, so would only stay in the sample for one year. They would also have experienced the deadline prior to the data period. The youngest cohort, those born in 1972, would be 39 years old in 2011. Likewise, they would only stay in the data period for one year, and they would experience the deadline after the data period. In other words, enrollees' experiences can be left censored or right censored. However, for those enrollees born between 1958 and 1962, they would spend all their 11 years between their 39th and 49th birthdays within the data period between 1997 and 2011. These enrollees constitute a balanced sample.

In total we use three samples. The nonswitching sample is used throughout. We use the general and balanced samples for robustness checks. We use the balanced sample for social cost calculation. Censoring happens in both nonswitching and general samples, but they have a lot more enrollees. Censoring does not happen in the balanced sample, but it is much smaller.

Disability insurance is employment based. Employment and job decisions are complex and conscious acts, so members in our sample have never been randomly assigned. However, the relevant issue is whether the insured and the uninsured suffer from uterine and ovarian problems in the same random fashion. If the illness incidence is uncorrelated between the insured and uninsured, then comparing their behavioral differences is valid. We are unaware of correlation between employment and the prevalence of medical problems in female reproductive organs. For almost 190,000 women in the 2004 U.S. Behavioral Risk Factor Surveillance Survey database, Erekson et al. (2009) find that women who were unemployed did not have higher odds of having hysterectomy than women who were employed. More important, as we will show in Figs. 3 and 4 below, the insured and uninsured have similar hazards in partial oophorectomy and myomectomy, which do not qualify for benefits. This is strong evidence that in terms of uterine and ovarian problems, the insured and uninsured share the same risks.

### 3.3. Summary statistics

The left half of Table 3 presents the summary statistics of the nonswitching sample in 2000, 2005 and 2010. The number of subjects ranges from 0.93 to 1.23 million in these years. Because each subject is included when she is between 39 and 49 years old in that sample year, there is a significant change in the distribution of birth cohorts across the years. In 2000, subjects born between 1960 and 1964 account for 17.9% of the subjects in that year, but those born between 1950 and 1954 account for 38%, and those born between 1955 and 1959 account for the rest. In 2005, the birth-year distribution shifts forward: none were born between 1950 and 1954, but 33.0% were born between 1955 and 1959, with the largest group (45.7%) being born between 1960 and 1964. For the year 2010, the subjects' birth-year distribution follows the same forward-shift pattern.

Table 3 also shows the distributions of the enrollees' insurance programs in the nonswitching sample. The percentages of enrollees having Government Employee Insurance are quite stable in the three years, ranging from 9.6% to 10.2% in the sample. Labor Insurance has the largest share of enrollment, about 50%, in each of the three years. However, the share of Farmer Insurance enrollments gradually declines over time. This is likely due to the diminishing and aging farmer population. Finally, the shares of the uninsured females seem to exhibit a slightly downward trend, declining from 31.0% in 2000 to 27.5% in 2010.

The right half of Table 3 shows the corresponding figures in the general sample. In contrast with the nonswitching sample, the general sample has a higher percentage of enrollees in Labor Insurance and uninsured groups. Enrollees in Government Employee Insurance and Farmer Insurance are less likely to change programs, so their shares become smaller without the nonswitching restriction. Likewise, a higher percentage of older cohorts can be observed because those enrollees are more likely to switch between insur-

**Table 3**
Summary statistics of female enrollees between 39 and 49 years old.

| | Nonswitching Sample | | | General Sample | | |
|---|---|---|---|---|---|---|
| | 2000 | 2005 | 2010 | 2000 | 2005 | 2010 |
| Birth year | | | | | | |
| 1950-54 | 37.7% | 0.0% | 0.0% | 32.3% | 0.0% | 0.0% |
| 1955-59 | 44.3% | 33.0% | 0.0% | 46.9% | 32.4% | 0.0% |
| 1960-64 | 17.9% | 45.7% | 29.9% | 20.7% | 47.2% | 34.0% |
| 1965-69 | 0.0% | 21.4% | 47.3% | 0.0% | 20.4% | 46.4% |
| 1970-74 | 0.0% | 0.0% | 22.8% | 0.0% | 0.0% | 19.6% |
| Insurance programs | | | | | | |
| Government Employee | 9.6% | 10.2% | 9.6% | 7.3% | 7.3% | 8.1% |
| Labor | 47.8% | 52.7% | 56.5% | 49.1% | 51.3% | 55.6% |
| Farmer | 11.7% | 9.0% | 6.3% | 9.7% | 7.5% | 6.2% |
| Uninsured | 31.0% | 28.2% | 27.5% | 33.9% | 33.8% | 30.1% |
| Surgery incidence rate per 100,000 | | | | | | |
| Hysterectomies | 766.5 | 582.8 | 526.7 | 702.1 | 556.2 | 516.0 |
| Myomectomies | 124.2 | 198.5 | 273.1 | 109.9 | 173.6 | 234.1 |
| Total oophorectomies | 146.2 | 67.4 | 55.2 | 127.4 | 63.6 | 57.5 |
| Partial oophorectomies | 93.7 | 246.9 | 267.3 | 81.6 | 220.7 | 236.3 |
| N (number of enrollees at year end) | 931,632 | 991,952 | 1,232,835 | 1,348,413 | 1,477,946 | 1,523,745 |

ance groups (e.g. from being employed to being unemployed and hence uninsured).

The lowest part of Table 3 displays the incidence rates of four surgeries in the nonswitching sample of women between 39 and 49 years old. Whereas hysterectomy incidence rate fell from 766 (per 100,000) in 2000 to 527 in 2010, myomectomy incidence rates almost doubled in the same time period. This likely indicates that myomectomy has become a more effective substitute for hysterectomy. Oophorectomy incidence rates declined over time, but the opposite was true for partial oophorectomy. Better diagnosis and more conservative treatments may account for these trends (which are also found in the general sample).

## 4. Econometric methods

Our hypothesis is that an enrollee's decision to undergo hysterectomy or oophorectomy may be significantly affected by the disability insurance. We test this at a cohort level because we lack data on individual or household income, marital status, or number of children. However, these data are available from SFIE for birth cohorts. If individual surgery decisions respond to incentives, enrollees as a group also respond similarly.

We group enrollees into cohorts by two discrete time scales: i) a natural time scale and ii) the amount of time from the 45th birthday. The natural time scale is represented by the vector $c \equiv (y, s)$, where $y$ is a year and $s$ is a season, or a three-month period of the year. An enrollee's birthday fits her into a birth cohort $c \equiv (y, s)$. Our sample consists of female enrollees born between 1948 and 1972, so we have 100 (= 25 years × 4 seasons) birth cohorts, with $y$ taking values of 1948, 1949,. . ., and 1972, and $s$ taking values of 1, 2, 3, and 4.

The second time scale measures how much time an enrollee has available before, or elapsed after, benefit expiration. We call the second time scale an enrollee's benefit quarter, and denote it by the variable $q$. The 91-day period that begins with the 45th birthday is called quarter 0; the next 91 days is quarter 1; the 91 days before quarter 0 is quarter -1, and so on. Enrollees in our sample are between 39 and 49 years old, so the benefit-quarter variable $q$ takes values -24, -23,. . ., -1, 0, 1,. . .,19. By making distinctions between year, season, and benefit quarters we allow for more decision variations.

Clearly, the choice of a 91-day length for a time unit, both for chronological and benefit dimensions, is for convenience and practicality. A shorter time length may imply sharper differences between adjacent cohorts because treatment incidences occur less

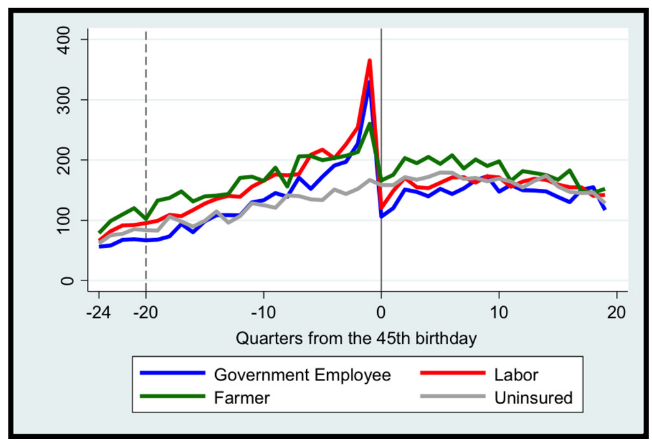


**Fig. 1.** Hysterectomy hazards.

frequently, whereas a longer time length reduces the number of groups. (We have also defined the cohort length to be six months, and have verified that results are similar.)

For each birth cohort in a given benefit quarter, the hysterectomy hazard is defined to be the ratio of the total number of enrollees undergoing hysterectomy within this benefit quarter to the total number of enrollees who have not undergone hysterectomy at the beginning of the benefit quarter. We define analogously the hazards of total oophorectomy, partial oophorectomy, and myomectomy. Hazards are calculated separately for the three insured and the uninsured groups. For easy presentation, we multiply the calculated hazards by 100,000. (We do the same for the regressions later.) In Figs. 1–4, we plot the hazards of the three insured groups and the uninsured group. The grey curve plots the hazards of the uninsured; the red curve is hazards of enrollees in Labor Insurance, whereas the blue and green curves are for those in Government Employee Insurance and Farmer Insurance, respectively. We use a different scale on the vertical in Fig. 1 because hysterectomy hazards are much larger than others.

The four figures show some striking patterns. First, in Fig. 1, Labor Insurance and Government Employee Insurance enrollees' hysterectomy hazards exhibit a sharp increase just before the 45th birthday, but drop significantly right after; a similar but less pronounced pattern is in Farmer Insurance. After a few quarters past the 45th birthday, hazards of all insured return to the same smooth trend. However, hazards of uninsured enrollees follow a smooth pattern throughout the entire time.

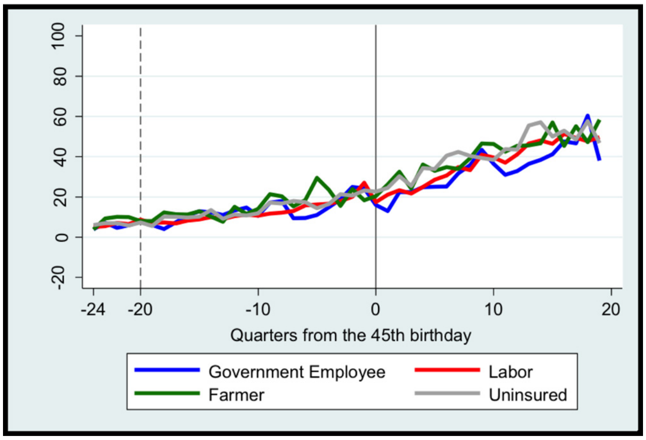


**Fig. 2.** Oophorectomy hazards.


**Fig. 3.** Partial oophorectomy hazards.

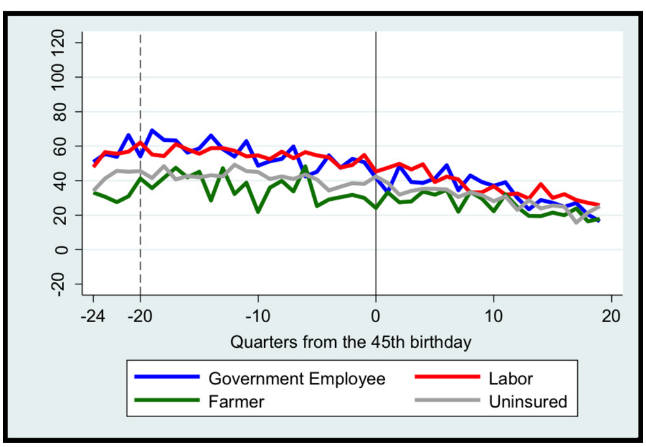


**Fig. 4.** Myomectomy hazards.

In Fig. 2, total oophorectomy hazards follow an increasing trend, but there is no apparent sharp increase just before the 45th birthday for Labor Insurance and Government Employee Insurance enrollees. In Figs. 3 and 4, myomectomy and partial oophorectomy hazards do not exhibit any abrupt changes.

There is no medical literature to support the pattern of hysterectomy in Government Employee, Labor, and Farmer Insurances. Adverse uterine conditions cannot be especially serious in the few quarters before the 45th birthday, but the opposite will happen the few quarters after. Our hypothesis is that such a pattern is caused

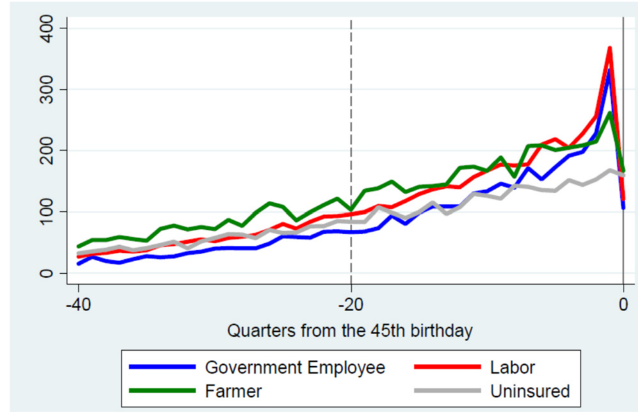


**Fig. 5.** Hysterectomy hazards from age 36 to age 45.

by the disability benefit expiration when enrollees turn 45 years old.

The hypothesis is consistent with the lack of any abrupt changes in myomectomy and partial oophorectomy hazards. Total oophorectomy indeed qualifies for the disability benefit before the 45th birthday. However, the removal of both ovaries carries much higher short-term and long-term health risks than the removal of the uterus. Because the same benefit is paid to both hysterectomy and oophorectomy, we should expect different responses.

For hysterectomy, the plots in Fig. 1 suggest a timing manipulation effect. Some hysterectomies may have been moved earlier to qualify for disability benefits, a timing effect. There is, however, a more serious possibility. Some hysterectomies may not have been performed absent the disability benefits, an inducement effect. We estimate these effects in two ways. The first is based on the difference-in-difference method: enrollees in the three insurance programs are to be compared to the uninsured, and we estimate dynamic, quarter-by-quarter effects. The second is a bunching-smoothing polynomial estimation based on a smoothness hypothesis: there should not be any abrupt changes in enrollees' probability of undergoing hysterectomy at the 45th birthday if there were no disability benefit. The bunching-smoothing polynomial method estimates a counterfactual hazard distribution for the insured as if the disability benefits were absent.

### 4.1. *Difference-in-difference by benefit quarters*

We estimate the difference of surgery experiences between the insured and the uninsured, the first difference. However, the disability insurance programs have been in place for the entire sample period, so there are no intervention date or "before-and-after" regimes. Theoretically the inducement effect would become relevant right at individuals' labor-market participation. However, reproductive problems that potentially lead to hysterectomies are uncommon before the fifth decade of life.[8] We assume that disability benefit is irrelevant due to absence of medical problems until enrollees turn 40 years old. Those years before the 40th birthday become the "before" regime, while the years after become the "after" regime; it is as if disability insurance intervention happens at each enrollee's 40th birthday. The validity of this assumption can be seen in Fig. 5: the insured and uninsured have almost identical trends of hysterectomy hazards from 35 to 40 years old (respec-

[8] In 2008, Taiwan age-specific hysterectomy incidence rates are 541 and 674 (per 100,000 women) for 40-44 and 45-49 year-olds, respectively; these are more than double than those for 30-34 and 35-39 year-olds (119 and 280). The hysterectomy incidence rate for 20-30 year-olds is less than 40 (see Figure 1 of Huang et al., 2016).

tively, 40 and 20 quarters to the 45th birthday). To implement this empirical strategy, we have chosen the 4 quarters between the 39th and 40th birthdays as the omitted benefit quarters. We adopt this assumption on the other three surgeries.

The three insurance groups (Government Employee Insurance, Labor Insurance, and Farmer Insurance) have different disability benefits, so we use a separate regression for each group. We present the regression equation for hysterectomy; the regression equations for the other three procedures can be set up analogously:

$$H_{c,q}^{Insured} = \alpha + \beta \times Insured + \sum_{i=-20}^{19} \gamma_i \times 1[i=q] + \sum_{i=-20}^{19} \rho_i \times 1[i=q] \times Insured + \mathbf{X}_{c,q}\eta + \sum_{j=1998}^{2011} k_j \times 1[j=T(c)] + \varepsilon_{c,q} \quad (1)$$

where $c \equiv (y, s)$ with $y = 1948, 1949, \ldots, 1972$ and $s = 1, 2, 3, 4,$ and $q = -24, -23, \ldots -1, 0, 1, 2, \ldots, 19.$

In equation (1), the dummy variable *Insured* is set to 1 for an insured group (Government Employee Insurance, Labor Insurance, or Farmer Insurance), and to 0 otherwise. The dependent variable $H_{c,q}^{Insured}$ is the hysterectomy hazard (multiplied by 100,000) of the insured or the uninsured of birth cohort $c$ at benefit quarter $q$, a birth cohort $c$ being defined by birth year $y$ and birth quarter $s$. The indicator function $1[i=q]$ is set at 1 if the condition inside the square brackets is satisfied; it is set at 0, otherwise. The covariates $\mathbf{X}_{c,q}\boldsymbol{\eta}$ are cohort-cell means of variables of the total number of children, the number of sons, marital status, and log household incomes (these data are from SFIE). The function $T(c)$ is used for the data-year fixed effects; $T(c) \equiv \text{Int}[y+45+s/4]$ is the smallest integer bigger than $(y+45+s/4)$, so its range is the years between 1997 and 2011. Finally, $\varepsilon_{c,q}$ is the error term. To mitigate serial correlation errors, we implement standard errors clustered by birth cohorts $c \equiv (y, s)$.[9]

The parameter $\rho_q$ in (1) is the mean hysterectomy hazard difference between quarter $q$ and the omitted quarters $q = -24$ to $q = -21$, those in age 39. The common time trend before age 40 has already been noted and shown in Fig. 5. Our assumption that inducement begins at $q = -20$ is conservative, so our estimates can be regarded as lower bounds. Furthermore, our results change only slightly when the benchmark age quarters are extended to those quarters for ages from 35 to 39. For $q = -20, \ldots, 19$, the parameter $\rho_q$ measures the incremental difference between the insured and the uninsured, our chief focus. If disability insurance does not affect enrollees' hysterectomy decisions, all estimates of $\rho_q$ should be zero.

The inducement effect is the total increment of hysterectomies of the insured over the uninsured in the period between the 40th and 50th birthdays. Let $\hat{\rho}_q$ denote the estimate of $\rho_q$. Let $n_q$ denote the number of enrollees who have not undergone hysterectomy at the beginning of quarter $q$. The inducement effect on hysterectomy is $\sum_{q=-20}^{19} \hat{\rho}_q \cdot n_q$. If this measure is zero, we conclude that the disability benefit has not increased the total number of hysterectomies among enrollees.

Next, the timing effect is the total number of hysterectomies that the insured would have undergone after the 45th birthday absent the benefit. If disability insurance incentivizes enrollees to have hysterectomies earlier, there will be fewer of them after the 45th birthday. The timing effect on hysterectomy is $\sum_{q=0}^{19} \hat{\rho}_q \cdot n_q$. If disability insurance has not favored earlier hysterectomies, then this measure will be zero.

Finally, our analysis is at the birth cohort level, and the dependent variable is hysterectomy hazard of enrollees born at a certain time. In effect, we use the number of enrollees at every birth cohort as weights in the estimation. Given that all the covariates within a birth cohort are constant for each enrollee, estimates obtained from the individual-level regression would be identical to those from the cohort-level regression (Lee and Card, 2008; Lemieux and Milligan, 2008).

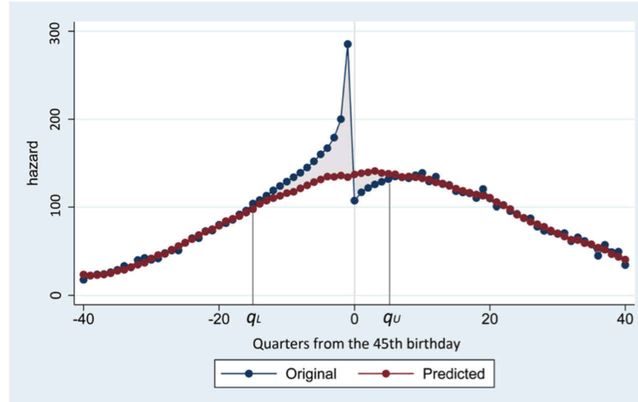


**Fig. 6.** Illustrative example of bunching-smoothing polynomial method.

### 4.2. Bunching-smoothing polynomial estimation

As an alternative, we use a bunching-smoothing polynomial estimation. The assumption is that without disability benefit expiration, there should not be any abrupt hysterectomy-hazard changes at age 45. For this estimation we have extended the data periods to 40 quarters before and after the 45th birthday, so these hazards are for ages between 35 and 55. We construct Fig. 6 by simulated data for an illustration. There, the blue curve plots the simulated empirical distribution of hysterectomy hazard of a hypothetical insured group. It shows the sudden hazard changes around the 45th birthday. To construct a counterfactual distribution, we imagine that the abrupt changes had not existed. We choose a lower quarter threshold and an upper quarter threshold, which are denoted, respectively, by $q_L$ and $q_U$, with $q_L < 0 < q_U$. We then use hazard data outside of quarters between $q_L$ and $q_U$ to fit an $N$th-order polynomial. The fitted curve is then used to predict the hazards between quarters $q_L$ and $q_U$. This is the red curve in Fig. 6. The interpretation is that quarter $q_L$ marks the beginning of disability insurance impact on hysterectomy before the 45th birthday, whereas quarter $q_U$ marks the end of the impact after the 45th birthday.

We use more observations outside the $q_L$ and $q_U$ thresholds than the difference-in-difference method for a better fit of the polynomial. The 20-year window of quarter ages doubles the time window for the difference-in-difference estimation. We augment the sample in the difference-in-difference analysis with enrollment and surgery records between 35 and 39 years old, and between 50 and 54 years old. These new data are used even if some enrollees have changed insurance programs between 35 and 39 years old, or between 50 and 54 years old. This is to maintain the same set of enrollees in the bunching-smoothing polynomial estimation as those in the difference-in-difference estimation.

[9] For details as to why the standard errors of the coefficient estimates of interest tend to be underestimated in the difference-in-difference model, see Bertrand et al. (2004) and Donald and Lang (2007).

For the uninsured and each of the insured groups, the counterfactual hysterectomy hazard regression is

$$H_{c,q} = \sum_{n=0}^{N} \alpha_n \times q^n + \sum_{i=q_L}^{q_U} \rho_i \times 1[i=q] + \varepsilon_{c,q} \quad (2)$$

where $c \equiv (y, s)$ with $y = 1948, 1949, \ldots, 1972$
and $s = 1, 2, 3, 4,$
and $q = -40, -23, \ldots -1, 0, 1, 2, \ldots, 39.$

In (2), $H_{c,q}$ is the hysterectomy hazard of birth cohort $c$ at benefit quarter $q$; $q^n$ is quarter $q$ raised to the power $n$; $q_L$ and $q_U$ are the lower and upper bounds; and $\varepsilon_{c,q}$ is the error term. Birth cohorts still range between 1948 and 1972, as in difference-in-difference estimation, but the quarter numbers now are from -40 to 39 because we incorporate more data points. Also, our data period spans 15 years, but we attempt to track enrollees' experiences for 20 years, so a balanced sample would be impossible.

Following Kleven and Waseem (2013), we use a fifth-order polynomial in the main specification ($N$ = 5). For each quarter between $q_L$ and $q_U$ we use a coefficient $\rho_j$ to capture the difference between the empirical and the counterfactual hazards at quarter $q$. If disability insurance has no effect on enrollees' hysterectomy decisions, all estimates of $\rho_j$ should be zero.

For each insured group, we use a grid search over the ranges of $q_L \in [-18, -9]$ and $q_U \in [2, 12]$ to select a pair of bounds that minimize the root mean squared error of the regression, a common optimality criterion in econometric models.[10] Because each insured group has its own optimal lower and upper thresholds, the number of estimated coefficients in each insured group is different. We define inducement and timing effects analogously as in difference-in-difference estimation. The inducement effect is $\sum_{q=q_L}^{q_U} \hat{\rho}_q \cdot n_q$, where $\hat{\rho}_q$ is the estimate of $\rho_q$ in equation (2), and $n_q$ is the number of enrollees who have not had hysterectomy at the beginning of quarter $q$. Likewise, the timing effect is $\sum_{q=0}^{q_U} \hat{\rho}_q \cdot n_q$.

## 5. Estimation results

### 5.1. Difference-in-difference estimation

We present estimation results in graphical plots. Fig. 7 plots the entire set of $\hat{\rho}_q$, $q$ = −20, .. ., 19. The red plots are for enrollees in Labor Insurance, the blue plots and the green plots are for enrollees in Government Employee Insurance and Farmer Insurance, respectively. Significant estimates are plotted with solid dots, whereas insignificant estimates are plotted with hollow dots. (The scale in plots of estimates for hysterectomy is different from those for other surgeries because of its hazard magnitude.)

In Fig. 7, for Labor Insurance enrollees, $\hat{\rho}_q$ starts at almost zero at $q$ = −20, gradually increases, and becomes significantly different from zero (solid dots) at $q$ = −14. Then $\hat{\rho}_q$ continues to increase as enrollee's age approaches 45, peaks at $q$ = −1 (the difference between the two groups being 193.8 cases per 100,000 enrollees at $q$ = −1) and then sharply declines at $q$ = 0. Most estimates after $q$ = 0 are small and insignificant. Likewise, the plot of Government

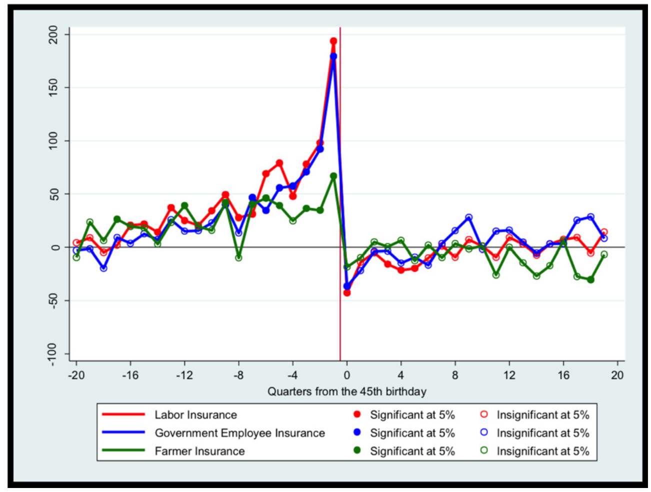


**Fig. 7.** Difference-in-difference estimates $\hat{\rho}_q$ for hysterectomy.

Employee Insurance group follows a similar pattern. The plots of Farmer Insurance group also peak at one quarter before age 45, though the magnitude is only half of the other two insurance groups.

Table A1 in Appendix A presents the difference-in-difference estimation results (only estimates $\hat{\rho}_q$ for $q$ between −10 and 7; most other estimates are insignificant). Each of the three columns in the table shows separate regression estimates. Due to censoring, the number of observation is 5,280, smaller than one would expect from a complete sample of balanced data (which would have 25 years × 4 seasons × 44 birth quarters × 2 insurance status or 8,800 observations).

In equation (1) the parameter $\beta$ measures the average difference between the insured and uninsured. The *Insured* dummy estimate is also in Table A1, and this is significant. For Labor Insurance and Farmer Insurance enrollees, their hysterectomy hazards are higher than the uninsured, and this is stronger for Farmer Insurance than Labor Insurance. For Government Employee Insurance enrollees, this difference turns out to be negative. The identification power is not diminished by the sign differences in $\hat{\beta}$ because the insured and uninsured share the same time trend. This can be seen from the insignificant coefficients in the first few quarters in Fig. 7.

Finally, equation (1) includes a number of controls. In all three equations, enrollees with higher household income are less likely to undertake hysterectomy, which suggests that wealthier households are less responsive to financial incentives. Enrollees with more children tend to have a smaller hysterectomy hazard, though this effect is insignificant for Government Employee Insurance enrollees.[11] Conditional on the total number of children, the number of sons does not seem to matter. Finally, being married is associated with a higher hazard, but the estimate is only significant for the Labor Insurance enrollees. Estimated coefficients from controls are consistent with common models of health care services.

We now turn to inducement and timing effects. Inducement effect on hysterectomy $\sum_{q=-20}^{19} \hat{\rho}_q \cdot n_q$ for enrollees in Labor Insurance is measured at 5,076 hysterectomies. This is about 11.6% of the total 43,845 hysterectomies undertaken by Labor Insurance enrollees between 40 and 49 years old in the sample period. The

[10] RMSE is a common measure for comparing the performance of different econometric models or parameter selections. For example, Ichimura (1993) proposes a semiparametric model and compares its RMSE to those of other models such as the truncated Tobit, binary choice, and duration models. RMSE is also the optimality criterion for selecting the smoothing parameter in nonparametric estimation methods (Ichimura and Todd, 2007); for selecting the bandwidth for regression discontinuity designs (Imbens and Kalyanaraman, 2012); and for selecting the polynomial order of the regression function of regression discontinuity designs (Lee and Lemieux, 2010).

[11] Studies have shown that the number of pregnancies (or living children) is negatively related to the prevalence of uterine fibroids (Ross et al., 1986; Chen et al., 2001).

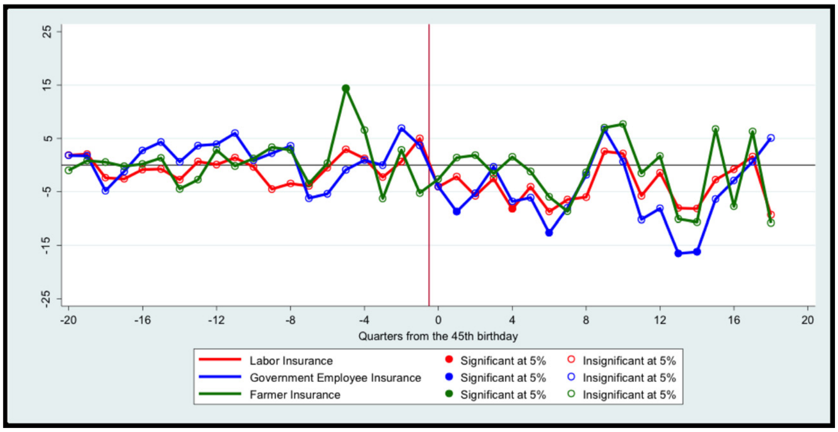


**Fig. 8.** Difference-in-difference estimates $\hat{\rho}_q$ for total oophorectomy.

standard error of total inducement effect is 857, strongly rejecting the hypothesis of no inducement effect. In fact, the 95% confidence interval for inducement effect is between 6,756 and 3,396, or between 7.8% and 15.4% of the total number of hysterectomies.

The timing effect is $\sum_{q=0}^{19} \hat{\rho}_q \cdot n_q$. Generally, hysterectomies have been expedited, so the timing effect will turn out to be negative. For ease of exposition, we omit the negative sign when we present timing effects. For Labor Insurance enrollees, the timing effect is measured at 1,008 hysterectomies, or at about 20% of the inducement effect, with the standard error at 695. Although the value of $\hat{\rho}_q$ at $q = 0$ is significantly negative for the Labor Insurance enrollees, the overall timing effect is not significantly different from zero. This is probably due to some hysterectomies having been moved earlier to the first few quarters after the 45th birthday.

In Government Employee Insurance, the inducement effect is measured at 789 hysterectomies, or about 11% of the total hysterectomy cases among Government Employee Insurance enrollees, while the timing effect is 143 cases. We reject the hypothesis of zero inducement effect, but not that of no timing effect. For Farmer Insurance enrollees, the inducement effect is smaller, at 347 cases, or about 3.8% of all hysterectomy surgeries among Farmer Insurance enrollees. The timing effect for Farmer Insurance is measured at 283 cases. Neither total inducement effect nor timing effect is significantly different from zero.

Regression results on hysterectomy hazards are strong evidence that enrollees respond to incentives created by the disability insurance program. The differences in inducement and timing effects in the three treatment groups are consistent with the differences in the three disability insurance programs. Benefits of Labor and Government Employee Insurance are higher than Farmer Insurance.

We now turn to regression results of total oophorectomy, partial oophorectomy, and myomectomy. Almost all estimates for equation (1) for these surgeries are insignificant. In Figs. 8–10 we plot the entire set of estimates of $\hat{\rho}_q$ for $q$ between −20 and 19, and use the same color convention for the three insurance groups. It is clear that the disability insurance program has not caused behavioral change. Tables A2, A3, and A4 in Appendix A presents the estimates (only estimates of $\hat{\rho}_q$ for $q$ between −10 and 7).

For partial oophorectomy and myomectomy, these insignificant results are to be expected because they are not eligible for benefits. The insignificant result for total oophorectomy is important. Total oophorectomy and hysterectomy have the same eligibility requirement and benefits. However, the health risks and long-term morbidity of total oophorectomy are much more severe than hysterectomy. The benefits are not enough to change enrollees' behavior.

### *5.2. Bunching-smoothing polynomial estimation*

Because the bunching-smoothing polynomial method does not rely on the existence of a control, one separate estimation is done for the uninsured and each of the three insured groups. The number of observation is 4,498 for the Labor Insurance, and 4,474 and 4,481 for the Government Employee and Farmer samples, respectively. These are smaller than those from a complete and balanced sample because of censoring and more missing observations when the data are extended to 20 years.

We present regression results with graphical plots and use the same color convention, with the additional grey plot for the uninsured. Estimates of hysterectomy equation (2) are plotted in Fig. 11. In Table A5 in Appendix A, the four columns list the estimates $\hat{\rho}_q$ for the uninsured, and the insured in different programs; the optimal bounds, $q_L$ and $q_U$, are at the bottom of each column. Because each group has its own optimal bounds, the number of estimated coefficients vary across different groups.

In Fig. 11, the gray line fluctuates minimally along the horizontal axis line, so the fifth-order polynomial fits the uninsured' hazard rates quite well. In fact, in Table A5 almost all estimates of $\hat{\rho}_q$ of the uninsured are insignificant, and we cannot reject the hypothesis that estimates of $\hat{\rho}_q$ are jointly zero (F statistics = 1.01). This serves to validate our bunching-smoothing polynomial approach.

For Labor Insurance, most estimates from $q = -11$ to $q = -1$ are significantly positive, followed by significantly negative estimates from $q = 0$ to $q = 4$; see Table A5. The red plots in Fig. 11 show the spike just before the 45th birthday, and then the drop. The pattern is similar to the difference-in-difference estimates. The estimated number of induced hysterectomies, $\sum_{q=q_L}^{q_U} \hat{\rho}_q \cdot n_q$, is 4,842, about 11% of total hysterectomies (43,845). The percentage is slightly smaller than the one (11.6%) estimated by the difference-in-difference method. The inducement effect has a standard error of 568, so the hypothesis of zero inducement is rejected.

The timing effect $\sum_{q=0}^{q_U} \hat{\rho}_q \cdot n_q$ is 722 hysterectomies, about 14.9% of the total inducement effect; it is somewhat lower than the corresponding percentage in the difference-in-difference estimates. More important, the timing effect is significantly different from zero due to a smaller standard error. This is because the timing effect for bunching-smoothing polynomial method covers only from zero to six quarters, while the difference-in-difference method covers up to 20 quarters, many of which have insignificant coefficients.

In Fig. 11 estimates $\hat{\rho}_q$ for Government Employee Insurance enrollees are significantly positive between $q = -7$ and $q = -1$, but significantly negative at $q = 0$ and $q = 1$; see also Table A5. We

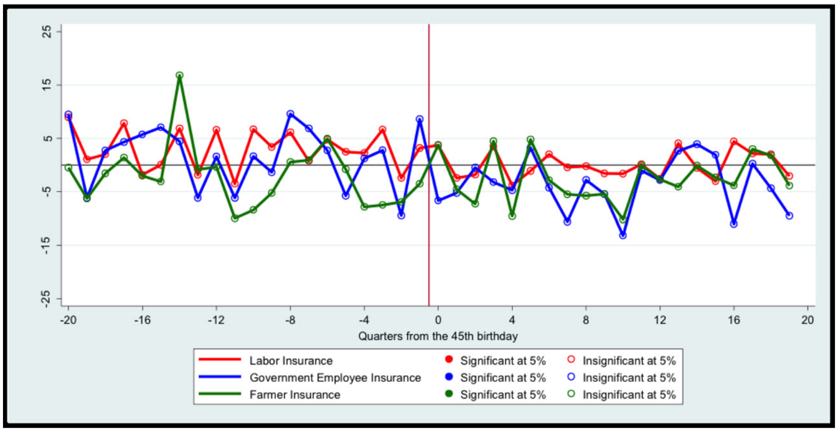


**Fig. 9.** Difference-in-difference estimates $\hat{\rho}_q$ for partial oophorectomy.

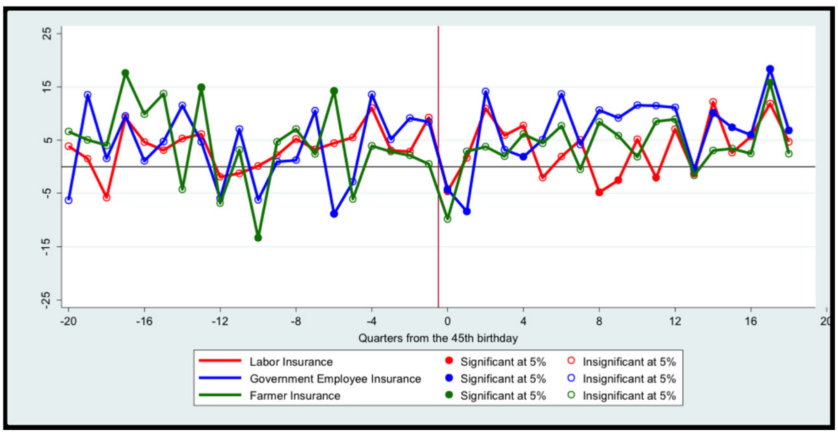


**Fig. 10.** Difference-in-difference estimates $\hat{\rho}_q$ for myomectomy.

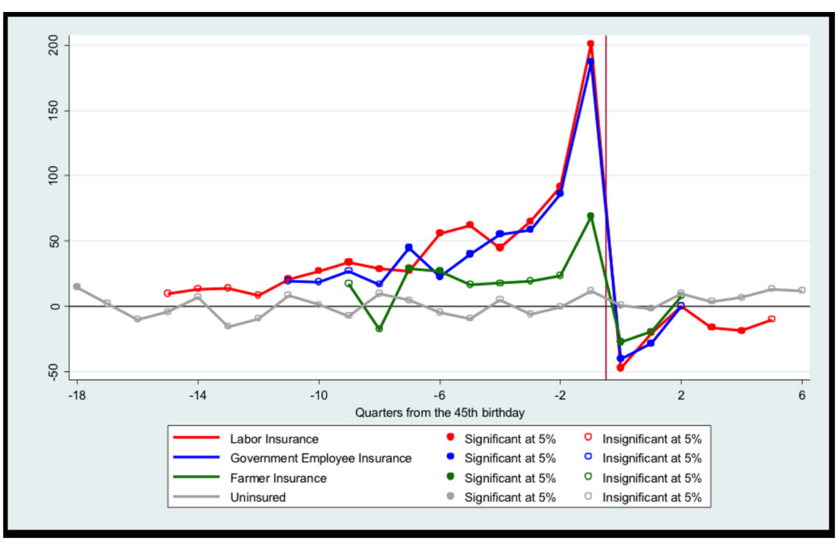


**Fig. 11.** Bunching-smoothing polynomial estimates $\hat{\rho}_q$ for hysterectomy.

obtain the estimated inducement and timing effects at 756 and 87 hysterectomies, respectively. These estimates are quite close to the corresponding difference-in-difference estimates (789 and 143 cases). Again, both the zero total inducement and the zero timing effect hypothesis is rejected.

Finally, in Fig. 11, the green curve plots those estimates $\hat{\rho}_q$ for Farmer Insurance enrollees; $\hat{\rho}_q$ is significantly positive at $q = -1$ and significantly negative at $q = 0$. Compared to Table A1, the estimates for Farmer Insurance in the last column of Table A5 in Appendix A have fewer coefficients significantly different from zero before age 45. The estimated inducement effect is 280 hysterectomies, which is near the difference-in-difference value. However, the estimated timing effect is only 60 hysterectomies, much smaller than the difference-in-difference estimate (283).

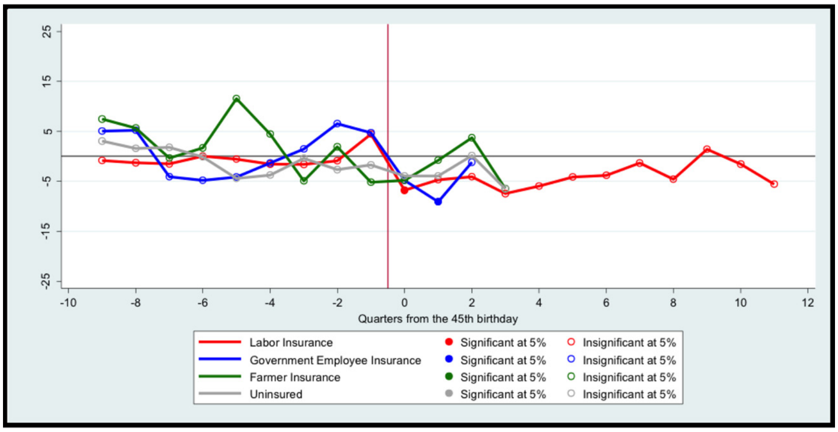


**Fig. 12.** Bunching-smooth polynomial estimates $\hat{\rho}_q$ for total oophorectomy.

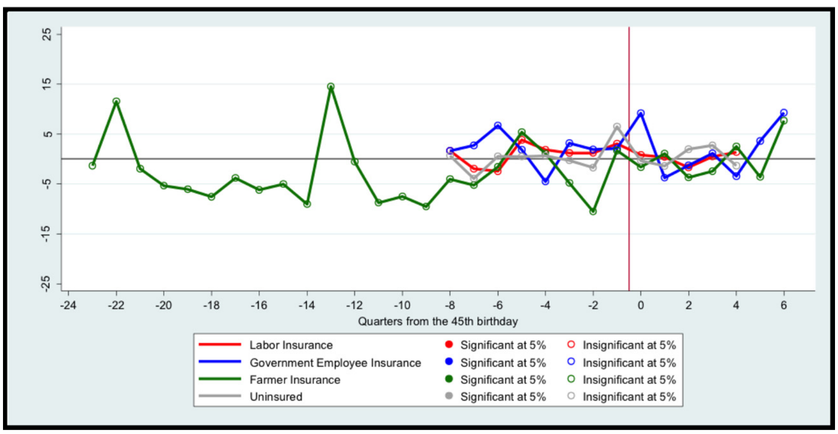


**Fig. 13.** Bunching-smoothing polynomial estimates $\hat{\rho}_q$ for partial oophorectomy.

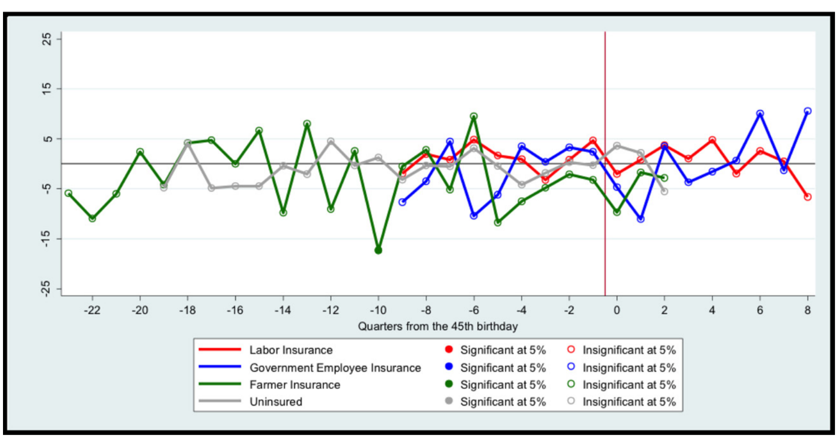


**Fig. 14.** Bunching-smoothing polynomial estimates $\hat{\rho}_q$ for myomectomy.

From the bunching-smoothing polynomial estimation, inducement and timing effects have larger impacts for Labor Insurances and the Government Employee Insurance enrollees, but less so for Farmer Insurance enrollees. However, compared to results of the difference-in-difference method, estimates of the bunching-smoothing polynomial estimation show a smaller timing effect in the three insurance groups, whereas the inducements effects are similar.

We now report results of the bunching-smoothing polynomial estimation for total oophorectomy, partial oophorectomy, and myomectomy. For partial oophorectomy and myomectomy, the fifth-order polynomial achieves a good fit, as most $\hat{\rho}_q$ are insignificant, and the corresponding F-test (all coefficients) is insignificant for the uninsured group. For total oophorectomy, however, the fifth-order polynomial fails the F test (F statistics = 11.22) and the sixth-order polynomial fits the function better and passes the F test (F statistics = 0.92). Hence, we present the results from estimating the sixth-order polynomial function. Figs. 12, 13, and 14 plot the estimates, and Tables A6, A7, and A8 in Appendix A present them and the optimal bounds. In Appendix B, we also plot actual

**Table 4**
Comparisons of observations between nonswitching, general, and balanced samples in 2005

| Insurance programs | (1) Nonswitching sample | (2) General sample | (3) (2)/(1) | (4) Balanced sample | (5) (4)/(1) |
|---|---|---|---|---|---|
| Government Employee Insurance | 100,745 | 107,696 | 1.07 | 43,577 | 0.43 |
| Labor Insurance | 522,462 | 758,909 | 1.45 | 218,357 | 0.42 |
| Farmer Insurance | 88,782 | 111,550 | 1.26 | 41,295 | 0.47 |
| Uninsured | 279,963 | 499,791 | 1.79 | 121,014 | 0.43 |
| Total number of observations | 991,952 | 1,477,946 | 1.49 | 424,243 | 0.43 |

(corresponding colors) and estimated counterfactual (dark gray) distributions for the four surgeries.

The two estimation methods yield very similar findings. First, for total oophorectomy, which qualifies for disability benefits, Fig. 12 shows that very few $\hat{\rho}_q$ are significantly different from zero in all insurance groups. Second, almost all the plots in Figs. 13 and 14 (for partial oophorectomy and myomectomy, respectively) are insignificant for every insurance group. Third, the inducement and the timing effects are negligible.

## 6. Robustness checks, benefit effects, and social costs

In this section, we investigate inducement and timing effects in more and less restrictive samples, and in subsamples stratified by different disability benefit levels. Then in the last subsection, we estimate the social costs due to the disability programs.

### 6.1. Sample without nonswitching restriction and sample without censoring

In this subsection, we use two different samples. First, we use a bigger, "general sample" consisting of all enrollees between the ages of 39 and 49, whether they have switched insurance programs or not. The general sample allows us to detect bias due to program switches. Our data only allow us to identify an enrollee's insurance status at the end of a calendar year, so we use the end-of-year insurance status for all quarters in that year. Then, we calculate the hazard rates for the enrollees in each insurance group for each quarter in the year. Second, we use a smaller, uncensored, "balanced sample" consisting of all enrollees born between 1958 and 1962 (see Table 2).

Table 4 lists the numbers of observations by insurance groups in the general and balanced samples in 2005. For comparison, we also provide the corresponding numbers in the nonswitching sample. In Table 4, in 2005, there are a little less than 1 million subjects in the nonswitching sample, but there are more than 1.47 million in the general sample. The general sample is about 49% larger than the nonswitching sample. By contrast, there are just over 0.42 million in the balanced sample, about 40% of the nonswitching sample.

Among the four groups, the ratios of general sample size to nonswitching sample size is the lowest for Government Employee Insurance, at 1.07. Government employees appear to have higher job stability. By contrast, the corresponding ratios of Labor Insurance and the uninsured are higher, at 1.45 and 1.79, respectively. Enrollees switching in and out of being employed and being unemployed is more common among those in Labor Insurance than those in either Government Employee Insurance or Farmer Insurance. The balanced sample consists of enrollees in the nonswitching sample born between 1958 and 1962, so naturally the corresponding ratios between sample sizes are stable, at about 40% of all insurance groups.

#### 6.1.1. Difference-in-difference estimation robustness

In Tables A9 to A12 in Appendix A, we present the difference-in-difference estimates of $\hat{\rho}_q$ of the general sample for hysterectomy, total oophorectomy, partial oophorectomy, and myomectomy, respectively; Tables A13 to A16 in Appendix A, correspondingly for the balanced sample. Table 5 presents the inducement and timing effects from difference-in-difference estimations. Only effects for hysterectomy are included; the effects for all the other three surgeries are negligible. We include results of the nonswitching sample for easy comparison.

From the first three rows in Table 5 for Labor Insurance, the inducement effect in the general sample is measured at 7,172 hysterectomies out of 61,692; this is about 11.6%. For the general sample, the standard error of the total inducement effect is 1,458. The inducement effect in the balanced sample is measured at 1,537 out of 13,609, or about 11.3%, with a standard error of 555. The corresponding percentage for the nonswitching sample is 11.6% (5,076/43,845). Induced hysterectomies as percentages of total hysterectomies remain stable in these three samples. The estimated timing effects in the three samples of Labor Insurance are in column (4) of Table 5. We tabulate the timing effect as a percentage of the inducement effect in column (5). The ratios of timing to inducement effects for the general and balanced samples are 16.8% and 25.2%, respectively; these compare with 19.9% of the nonswitching sample. Nonetheless, from column (4), none of the timing effects is significantly different from zero.

For Government Insurance enrollees, from Table 5, the total inducement effect is measured at 11.2% of total hysterectomy, and the timing effect at 17.6%, whereas the corresponding percentages in the nonswitching sample are 10.9% and 18.1%. These estimates confirm that results in the general and nonswitching samples are stable. We do not include the results of the balanced samples for Government Employee Insurance and Farmer Insurance because the explanatory variables in these small samples exhibit very limited variations.

The last two rows in Table 5 are the summaries of the estimations of Farmer Insurance. The total inducement effect in the general sample is small, at 241 hysterectomies, or 2.2% of total hysterectomies. Although the number is even smaller than the total inducement effect of 347 in the nonswitching sample, the results may be driven by the imprecise estimates of coefficients after age 45. For enrollees in Farmer Insurance, the inducement effect in the general sample is 2.2% of total hysterectomies, and it is lower than the 3.8% in the nonswitching sample. For the timing effect, the general sample is about 20 percentage points higher than the 81.6% (of the inducement effect) of the nonswitching sample.

#### 6.1.2. Bunching-smoothing polynomial estimation robustness

Next, we turn to bunching-smoothing polynomial estimates. We only compare the results of the general and the nonswitching samples because no balanced sample can be constructed due to the 20-year sample window. Table 6 summarizes the inducement and timing effects. Estimates of $\hat{\rho}_q$ for the general sample are in Tables A17 to A20 in Appendix A. For Labor Insurance, the inducement effect is measured at around 11% of total hysterectomy for both nonswitching and general samples. The timing effects are, respectively, 14.9% and 15.6% of the corresponding inducement effects for the general and nonswitching samples. The inducement and timing

**Table 5**
Hysterectomy inducement and timing effects from difference-in-difference estimates

| Insurance types | Sample | (1) Total hysterectomies from 40 to 49 | (2) Total Inducement effect | (3) (2)/(1) | (4) Timing effect | (5) (4)/(2) |
|---|---|---|---|---|---|---|
| Labor Insurance | Nonswitching sample | 43,845 | 5,076** | 11.6% | 1,008 | 19.9% |
| | | | (857) | | (695) | |
| | General sample | 61,692 | 7,172** | 11.6% | 1,202 | 16.8% |
| | | | (1,458) | | (1,382) | |
| | Balanced sample | 13,609 | 1,537** | 11.3% | 387 | 25.2% |
| | | | (555) | | (1,290) | |
| Government Employee Insurance | Nonswitching sample | 7,262 | 789** | 10.9% | 143 | 18.1% |
| | | | (209) | | (650) | |
| | General sample | 7,888 | 885** | 11.2% | 156 | 17.6% |
| | | | (286) | | (347) | |
| Farmer Insurance | Nonswitching sample | 9,100 | 347 | 3.8% | 283 | 81.6% |
| | | | (284) | | (190) | |
| | General sample | 10,987 | 241 | 2.2% | 241* | 100.0% |
| | | | (1,418) | | (110) | |

Note: Robust standard errors clustered at the birth cohort level are in parentheses. * $p < 0.05$, ** $p < .01$.

**Table 6**
Hysterectomy inducement and timing effects from bunching-smoothing polynomial estimates

| Insurance types | Sample | (1) Total hysterectomies from 40 to 49 | (2) Total inducement effect | (3) (2)/(1) | (4) Timing effect | (5) (4)/(2) |
|---|---|---|---|---|---|---|
| Labor Insurance | Nonswitching sample | 43,845 | 4,842** | 11.0% | 722** | 14.9% |
| | | | (568) | | (163) | |
| | General sample | 61,692 | 6,736** | 10.9% | 1,053** | 15.6% |
| | | | (785) | | (214) | |
| Government Employee Insurance | Nonswitching sample | 7,262 | 756** | 10.4% | 87** | 11.5% |
| | | | (108) | | (28) | |
| | General sample | 7,888 | 864** | 11.0% | 135 | 15.6% |
| | | | (185) | | (136) | |
| Farmer Insurance | Nonswitching sample | 9,100 | 280** | 3.1% | 60 | 21.4% |
| | | | (103) | | (35) | |
| | General sample | 10,987 | 319** | 2.9% | 84* | 26.3% |
| | | | (125) | | (33) | |

Note: Robust standard errors clustered at the birth cohort level are in parentheses. * $p < 0.05$, ** $p < .01$.

effects are both significantly different from zero. These results indicate robustness of estimates between the general and nonswitching samples.

For Government Employee Insurance, the inducement effects in the general sample and nonswitching sample are, respectively, 10.4% and 11% of corresponding total hysterectomies. The timing effects in the general and nonswitching samples are 11.5% and 15.6%, respectively, of inducement effects. These results indicate robustness. Likewise, for Farmer Insurance, the total inducement effects in the general and nonswitching samples are quite similar, measured at 3.1% and 2.9% of the corresponding hysterectomy, with the timing effect being 21.4% and 26.3%, respectively, of inducement. Whereas a smaller timing effect is obtained from the bunching-smoothing polynomial method, especially for Farmer Insurance, we confirm the timing effect in most estimates.

### 6.2. Inducement and disability benefit

We now investigate the relationship between benefit levels and the inducement and timing effects. This is an issue pertinent to current policy discussions because the Taiwanese government is considering reducing disability benefits.[12] We stratify our sample into 5 groups of increasing insurance salaries with roughly equal numbers of observations in each group.

The stratification analysis is only on enrollees of Labor Insurance, for two reasons. First, from Table 3, the sample size of Labor Insurance is at least 5 times larger than Government Employee Insurance, and 4 times larger than Farmer Insurance. The large sample size allows us to obtain more reliable estimates. Second, in contrast with other insurance groups, we have more accurate benefit information from Labor Insurance. We have data of an enrollee's (mandated) National Health Insurance premium. Because the premium is a fixed percentage of salaries, we can infer enrollees' salaries. This inference is accurate for those in the Labor Insurance program. However, public employees often receive stipends, so the inference from National Health Insurance premium is inaccurate. In Labor Insurance the disability benefit is fixed at 5.3 months of insurance salary, capped at NT$43,900.

For each of the 5 groups of increasing salaries, we use the difference-in-difference and bunching-smoothing polynomial methods to estimate the number of induced hysterectomies and the inducement rate, the ratio of induced hysterectomies to total hysterectomies of enrollees between the ages of 40 and 49. Also, we show the estimated number of hysterectomies due to the timing effect, and the ratio of timing effect to inducement effect. Table 7 presents the results, with the difference-in-difference and bunching-smoothing polynomial estimation results in the upper and lower panels, respectively. Column (1) lists the average disability benefits for the 5 groups. The average disability benefit of group 1 is around NT$84,000, nearly one third of the average benefit of the highest group 5 which has an average of almost NT$220,000. The maximum allowed disability benefit is approximately NT$232,600 (5.3 $\times$ NT$43,900), but the average disability benefits of group 5 is

[12] Popular discussions have pointed to a link between disability benefits and hysterectomies, and pundits have advocated to reduce infertility disability benefits. In response, the Bureau of Labor Insurance has shown a weak correlation between economic fluctuations and numbers of women receiving infertility benefits. Nonetheless, no causality between infertility benefits and hysterectomies has been established; see Yeh (2013) for details.

**Table 7**
Hysterectomy inducement effects of stratified nonswitching Labor Insurance enrollees

| Subgroups | (1) Average disability benefits | (2) Total hysterectomies 40-49 years old | (3) Induced hysterectomies | (4) Inducement rate | (5) Timing effect | (6) Timing rate |
|---|---|---|---|---|---|---|
| D-in-D | | | | | | |
| 1 | NT$84,592 | 8,280 | 739 | 8.93% | 135 | 18.20% |
| | | | (277) | | (134) | |
| 2 | NT$100,425 | 9,145 | 1,060 | 11.60% | 161 | 15.17% |
| | | | (293) | | (101) | |
| 3 | NT$133,435 | 8,722 | 949 | 10.88% | 233 | 24.51% |
| | | | (214) | | (146) | |
| 4 | NT$185,197 | 9,049 | 1,319 | 14.58% | 119 | 9.02% |
| | | | (255) | | (359) | |
| 5 | NT$219,500 | 8,631 | 1,356 | 15.71% | 167 | 12.31% |
| | | | (193) | | (97) | |
| Bunching | | | | | | |
| 1 | NT$84,592 | 8,280 | 754 | 7.11% | 40 | 5.31% |
| | | | (99) | | (49) | |
| 2 | NT$100,425 | 9,145 | 854 | 9.88% | 131 | 15.34% |
| | | | (162) | | (74) | |
| 3 | NT$133,435 | 8,722 | 924 | 9.72% | 198 | 21.44% |
| | | | (416) | | (167) | |
| 4 | NT$185,197 | 9,049 | 1,255 | 16.80% | 72 | 5.74% |
| | | | (187) | | (30) | |
| 5 | NT$219,500 | 8,631 | 1,461 | 14.45% | 203 | 13.89% |
| | | | (337) | | (68) | |

Note: Robust standard errors clustered at the birth cohort level are in parentheses; ** $p < 0.01$, * $p < 0.05$.

only a little lower than this maximum, so a sizable proportion of enrollees in this group have actual salaries above the cap.

Columns (2) and (3), respectively, present total numbers of hysterectomies, estimated induced hysterectomies, and standard errors. Total hysterectomies of each group are similar, with the percentage difference between the highest and the lowest group at less than 10%. By contrast, the variation of induced hysterectomies is quite large among different benefit groups: induced hysterectomies of the highest-benefit group 5 are about twice the lowest-benefit group 1. Under the assumption that the two inducement effects are uncorrelated, we use a *t*-test to reject marginally the hypothesis that the inducement hysterectomy in group 5 is the same as group 1.

The estimated inducement rates are in Column (4). The inducement rate increases with average disability benefit: the ratio of induced hysterectomies to total hysterectomies increases modestly from group 1 to group 3 (from about 9% to11%), but accelerates from group 3 to group 5 (from about 11% to 15%). The estimated number of hysterectomies and the timing rates are shown in columns (5) and (6), respectively. On average, timing effect is small relatively to the number of induced hysterectomies, less than 15% in most groups, though enrollees in the middle income groups have a rate slightly over 20%. In total, in the difference-in-difference estimates, the highest benefit group's inducement rate is about 75% larger than the lowest income group (15.71% versus 8.93%). The corresponding results in bunching-smoothing polynomial estimates are stronger, with group 5's inducement rate being more than twice that of group 1 (14.45% versus 7.11%).

Stratification analysis shows that benefits have a strong and positive effect on inducement. Results in Table 7 shed some light on the possible impact of a policy change.[13] The current discussion may recommend reducing half of the benefit. If this were to happen, for group 5 the average benefit would drop from NT$220,000 to NT$110,000, falling between the average benefit of group 3 and group 2. At a projected inducement effect at 11%, this would result in a reduction of more than 4.5 percentage points from the current inducement effect of 15.71%. If the benefit is paid at a fixed price, say at the current third tier, we predict that inducement effects will become stronger among low-income enrollees, and weaker among high-income enrollees.

### 6.3. Social costs due to disability insurance

We now estimate social costs due to induced surgeries and disability benefit payments. Each induced hysterectomy qualifies an enrollee for benefit that would not have been paid. One can plausibly argue that the benefit is a transfer; we are agnostic about the desirability or efficiency of the benefit transfers due to inducement. Each induced hysterectomy is a surgery which uses real resources. Admittedly a hysterectomy may yield some short-term and long-term health gains, but we are not in a position to estimate them.[14] Here, we calculate separately the inducement costs due to benefit payments and surgeries.

We assess inducement costs by the balanced sample (those born between 1958 and 1962) because all enrollees' experiences from their 40th to 50th birthdays happen within the data period of 1997 to 2011. We estimate the social costs of the three programs separately. Inducement effects have only been estimated for the Labor Insurance balanced sample. However, from Table 5, for Labor Insurance, the inducement effects for the nonswitching and balanced samples are similar. We believe that the same would hold for the nonswitching and balanced samples in Government Employee Insurance and Farmer Insurance. Hence, we simply use the inducement effect percentages in the nonswitching sample.

We estimate the hysterectomy reimbursements from National Health Insurance as follows. In Taiwan hysterectomies are classified by three broad surgical intensities (total, subtotal, and laparoscopic), as well as by three levels of teaching hospital characteristics

[13] Our results are different from those in Ho et al. (2018). They find that the hysterectomy rate declines as the benefits increase. We suspect three reasons for this discrepancy. First, we differentiate between inducement and timing effects. Second, Ho et al. (2018) miscalculate the insurance salary of public employees (whose insurance salary was only a fraction of the full salary due to stipends). Third, women in the farmer insurance also were entitled to infertility benefits and therefore should not be included in the control group.

[14] Note also that Taiwanese enjoy national health insurance. Women would have assessed hysterectomy health gains whether or not they were covered by disability insurance. Hence, induced hysterectomies due to disability insurance lead to deadweight loss.

**Table 8**
Estimated social costs of disability insurance (balanced sample)

| Insurance programs | Total number of enrollees | Monthly insurance salary | Total number of hysterectomies | Inducement disability benefit payment in millions | Inducement surgical cost in millions |
|---|---|---|---|---|---|
| Government Employee Insurance | 43,577 | NT$33,786 | 2,740 | NT$60.543 | NT$15.322 |
| Labor Insurance | 218,357 | NT$31,578 | 14,946 | NT$306.577 | NT$89.732 |
| Farmer Insurance | 41,295 | NT$10,200 | 2,740 | NT$60.543 | NT$15.322 |
| Total for three programs | 303,229 | | 20,426 | NT$427.663 | NT$120.376 |

(major teaching, minor teaching, and community). National Health Administration sets a separate reimbursement rate for each of these 9 hysterectomy classes. We pick the mid-point, year 2005, for the reimbursement rates. We multiply the number of hysterectomies in each of the 9 classes by the corresponding reimbursement rate; hysterectomy cost is the sum of these 9 products. Details for the disaggregated numbers of hysterectomies and the 2005 reimbursement rates are in Table A21 of Appendix A.

Table 8 presents the aggregated data summary and the inducement costs. The first column lists the numbers of enrollees in the 1958-1962-cohort balanced sample. There are 303,229 enrollees in all three programs. The second column lists the average monthly insurance salary by programs. For Government Employee Insurance, the insurance salary is the lower of an enrollee's base monthly salary and NT$53,900. However, National Health Insurance records include base salary and stipends. For disability benefit estimation, we use the average base salary for those who have worked for 10 years. This is NT$33,786 in the 2005 reports of Government Employee Insurance. For Labor Insurance, the insurance salary is defined to be the lower of an enrollee's actual monthly salary and NT$43,900. Based on the insurance salaries of female enrollees who underwent hysterectomies, we obtain the average insurance salary per month, NT$31,578. For Farmer Insurance, the insurance salary is fixed at NT$10,200 per month.

The third column lists the numbers of hysterectomies in each and all programs. Estimates of induced disability benefit payment and surgical costs are in the next two columns. Recall the benefit is 6 months of insurance salary for Government Insurance and 5.3 months for Labor Insurance and Farmer Insurance, so total payment is equal to the monthly amount multiplied by the corresponding months in the program. Then we multiply the total payment by the inducement rates in each insurance program in Table 5 to obtain the induced benefit payment. We follow a similar procedure to estimate the surgery costs due to inducement.

For the total of over 303,000 enrollees, we estimate a total over NT$427 millions benefits payment due to induced hysterectomies, so it is NT$1,410 per enrollee. We estimate a surgical cost over NT$120 millions due to inducement, so it is just under NT$400 per enrollee. To give a sense of the magnitude of these numbers, we find that the 2016 reimbursement rates for mammogram and pap smear were, respectively, NT$1,245 and NT$80. Hence, the induced benefit payment would be more than enough to fund 1 mammogram, and the surgery cost due to induced hysterectomy would fund 5 pap smears, for each enrollee.

## 7. Conclusions

We have studied enrollees' response to the infertility coverage in three Taiwanese disability insurance programs. Enrollees having hysterectomy or complete oophorectomy qualify for benefit, but the eligibility ends at the 45th birthday. This program arguably can be likened to a natural experiment of putting a price on the removal of a human organ. Compared to the uninsured, enrollees have about 11% more hysterectomies, and about 20% of the induced hysterectomies could be classified as those expedited to beat the deadline. Disability insurance has not led to any increase in oophorectomy.

The contrast between the different responses in hysterectomy and oophorectomy is striking. The plausible explanation behind the difference is a cost-benefit calculus. Because organ removal is a discrete choice, economic principle dictates that such an operation is undertaken if and only if the net reward is above a threshold. If a policy goal is an amount of insurance that would not result in induced operations, then our results indicate that, in the Taiwanese case, the benefit is above the threshold for hysterectomy, but below for oophorectomy. A policy implication, therefore, is that insurance coverage for infertility should depend on whether the infertility is due to hysterectomy or oophorectomy.

The inefficiency in health insurance is moral hazard, due to health care cost subsidization. The inefficiency in disability insurance is excessive claims, due to benefits from filing. In the Taiwanese case, the filing for disability benefit claims requires surgeries, which are covered by national health insurance. This has led to a double moral hazard, and we have found that the cost can be significant.

Acknowledgements

## Acknowledgement

We thank editor Luigi Siciliani and two reviewers for their advice. We also thank Stacey Chen, Minchung Hsu, Tor Iversen, Kevin Lang, Nidhiya Menon, Brett Wendling, Tzu-Ting Yang, Chunyu Yeh and seminar participants at Boston University, Brandeis University, Hong Kong Baptist University, Indiana University-Purdue University Indianapolis, Institute of Economics at Academic Sinica, International Industrial Organization Conference in Indianapolis, Keio University, Paris School of Economics, Queen's University, University of Bologna, University of New South Wales, University of Oslo, and University of Southern Denmark for their valuable comments and suggestions. We are grateful to Johannes Schmieder for generously providing us with codes that assisted us in the bunching-smoothing polynomial estimation, and the Taiwanese National Health Research Institute for providing National Health Insurance Data. Support from National Science Council (MOST 105-2410-H-004-004 to Hsienming Lien) is greatly appreciated. The paper represents the authors' views and does not reflect those of the Bureau of National Health Insurance or the National Science Council.

## Appendices A and B. Supplementary Data

Supplementary data associated with this article can be found, in the online version, at https://doi.org/10.1016/j.jhealeco.2019.04.001.

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# Appendix A

Table A1: Difference-in-difference estimates $\hat{\rho}_q$ for hysterectomy in nonswitching sample

| Quarter to 45th birthday $q$ × *Insured* $\widehat{\rho}_q$ | (1) Labor Insurance Insurance | (2) Government Employee Insurance | (3) Farmer Insurance |
|---|---|---|---|
| -10 | 34.18** | 22.65 | 15.70 |
| | (7.950) | (12.06) | (15.01) |
| -9 | 49.37** | 39.66** | 41.90* |
| | (8.231) | (14.67) | (16.79) |
| -8 | 27.68** | 13.19 | -10.03 |
| | (9.025) | (12.78) | (13.61) |
| -7 | 31.19** | 46.67** | 40.20* |
| | (7.053) | (16.19) | (15.74) |
| -6 | 69.09** | 34.25** | 46.10** |
| | (9.824) | (11.08) | (15.98) |
| -5 | 79.12** | 55.79** | 38.98* |
| | (8.240) | (15.62) | (15.46) |
| -4 | 47.85** | 57.38** | 24.64 |
| | (8.316) | (16.96) | (15.52) |
| -3 | 78.11** | 70.66** | 36.32** |
| | (10.81) | (14.46) | (13.09) |
| -2 | 97.91** | 92.00** | 34.47* |
| | (11.05) | (15.91) | (15.24) |
| -1 | 193.8** | 179.2** | 66.70** |
| | (14.95) | (19.70) | (15.91) |
| 0 | -42.88** | -36.57** | -18.56 |
| | (9.071) | (13.37) | (13.83) |
| 1 | -14.10 | -21.98 | -9.601 |
| | (10.70) | (13.94) | (16.11) |
| 2 | -4.997 | -4.015 | 4.841 |
| | (8.992) | (12.62) | (16.31) |
| 3 | -15.78* | -3.447 | 0.480 |
| | (7.703) | (13.86) | (15.61) |
| 4 | -21.51* | -14.79 | 6.320 |
| | (8.839) | (14.65) | (14.86) |
| 5 | -19.64* | -9.188 | -12.71 |
| | (9.068) | (14.54) | (15.06) |
| 6 | -10.01 | -16.81 | 1.950 |
| | (10.21) | (12.54) | (15.08) |
| 7 | 1.204 | 3.337 | -9.745 |
| | (7.572) | (15.31) | (14.17) |
| *Insured* | 8.764** | -17.23** | 33.22** |
| | (3.289) | (4.228) | (5.825) |
| Log household income | -12.10* | -8.788* | -25.33** |
| | (5.502) | (4.044) | (5.940) |
| Total number of children | -20.34* | -11.82 | -18.43* |
| | (8.306) | (8.496) | (7.395) |
| Number of sons | 4.045 | 0.544 | -1.099 |
| | (10.98) | (10.57) | (10.32) |
| Married | 48.33* | 38.68 | 25.93 |
| | (18.66) | (21.29) | (23.07) |
| Estimated inducement effect | 5,076 | 789 | 347 |
| Estimated timing effect | 1,008 | 143 | 283 |
| Observations | 5,280 | 5,280 | 5,280 |

Notes: The dependent variable is quarterly hazard of hysterectomy. Uninsured are used as baseline. Other covariates are full sets of quarter dummies and data year fixed-effects. Robust standard errors clustered at the birth cohort level are in parentheses. $^{**}, p < 0.01$; $^{*}, p < 0.05$.

Table A2: Difference-in-difference estimates $\hat{\rho}_q$ for total oophorectomy in nonswitching sample

| | (1) Labor Insurance | (2) Government Employee Insurance | (3) Farmer Insurance |
|---|---|---|---|
| Quarter to 45th birthday x Insurance group dummy ($\rho_q$) | | | |
| -10 | 1.322 | 1.253 | 1.097 |
| | (2.332) | (3.223) | (3.903) |
| -9 | -3.002 | 2.434 | 3.219 |
| | (2.618) | (3.894) | (4.645) |
| -8 | -2.147 | 3.661 | 2.748 |
| | (2.297) | (4.424) | (3.968) |
| -7 | -2.621 | -6.168 | -3.441 |
| | (2.201) | (3.430) | (3.911) |
| -6 | 0.848 | -5.396 | 0.444 |
| | (2.890) | (3.815) | (4.955) |
| -5 | 4.258 | -0.894 | 14.55* |
| | (3.069) | (3.592) | (5.769) |
| -4 | 2.538 | 0.874 | 6.783 |
| | (2.453) | (4.557) | (5.359) |
| -3 | -0.706 | 0.315 | -6.207 |
| | (2.728) | (4.615) | (3.719) |
| -2 | 2.469 | 7.489 | 2.752 |
| | (3.162) | (5.301) | (4.239) |
| -1 | 7.006 | 4.597 | -5.469 |
| | (3.617) | (4.361) | (4.949) |
| 0 | -1.808 | -2.760 | -2.991 |
| | (2.910) | (4.783) | (4.956) |
| 1 | -0.407 | -7.569* | 0.913 |
| | (3.246) | (3.791) | (4.776) |
| 2 | -4.463 | -4.166 | 1.299 |
| | (4.402) | (5.232) | (5.667) |
| 3 | -1.682 | 0.717 | -2.245 |
| | -3.391 | (5.211) | (4.900) |
| 4 | -7.928* | -5.818 | 0.771 |
| | (3.890) | (5.175) | (6.893) |
| 5 | -3.677 | -5.301 | -1.771 |
| | (4.141) | (6.050) | (7.327) |
| 6 | -8.167 | -11.98* | -6.345 |
| | (4.210) | (5.907) | (6.240) |
| 7 | -5.776 | -7.501 | -8.922 |
| | (5.318) | (6.522) | (5.574) |
| Insurance group dummy | -5.394** | -6.718** | 5.132* |
| | (1.171) | (1.527) | (2.229) |
| Logged household income | 5.885** | 3.654 | 3.984 |
| | (2.197) | (1.976) | (3.205) |
| Total number of children | -38.27** | -29.59** | -26.52** |
| | (4.063) | (4.037) | (3.581) |
| Number of sons | -11.41* | -11.22* | -0.206 |
| | (5.170) | (4.796) | (4.067) |
| Married | 20.60 | 30.74** | 31.15** |
| | (11.16) | (8.725) | (10.58) |
| Observations | 5,280 | 5,280 | 5,280 |

Note: The dependent variable is quarterly hazard of total oophorectomy. Uninsured are used as baseline. Other covariates are full sets of quarter dummies and data year fixed-effects. Robust standard errors clustered at the birth cohort level are in parentheses. $^{**}, p < 0.01$; $^{*}, p < 0.05$.

Table A3: Difference-in-difference estimates $\hat{\rho}_q$ for partial oophorectomy in nonswitching sample

| | (1) Labor Insurance | (2) Government Employee Insurance | (3) Farmer Insurance |
|---|---|---|---|
| Quarter to 45th birthday x Insurance group dummy ($\rho_q$) | | | |
| -10 | 6.664 | 1.650 | -8.454 |
| | (4.098) | (5.974) | (5.362) |
| -9 | 3.377 | -1.380 | -5.248 |
| | (3.827) | (6.287) | (6.936) |
| -8 | 6.101 | 9.577 | 0.529 |
| | (4.223) | (5.634) | (5.606) |
| -7 | 0.775 | 6.849 | 0.920 |
| | (4.459) | (6.323) | (6.117) |
| -6 | 4.781 | 2.719 | 4.938 |
| | (4.148) | (7.696) | (6.284) |
| -5 | 2.480 | -5.745 | -0.803 |
| | (4.200) | (5.337) | (7.039) |
| -4 | 2.270 | 1.219 | -7.867 |
| | (3.806) | (5.776) | (6.671) |
| -3 | 6.616 | 2.759 | -7.514 |
| | (3.715) | (6.021) | (6.135) |
| -2 | -2.445 | -9.461 | -6.953 |
| | (4.228) | (6.822) | (7.480) |
| -1 | 3.166 | 8.600 | -3.529 |
| | (3.692) | (5.339) | (6.099) |
| 0 | 3.692 | -6.660 | 3.732 |
| | (4.042) | (5.372) | (5.971) |
| 1 | -2.439 | -5.250 | -4.569 |
| | (3.797) | (5.829) | (5.561) |
| 2 | -1.826 | -0.479 | -7.287 |
| | (3.964) | (7.889) | (6.496) |
| 3 | 3.501 | -3.201 | 4.472 |
| | (3.821) | (4.598) | (5.777) |
| 4 | -3.862 | -4.727 | -9.538 |
| | (3.103) | (6.147) | (5.517) |
| 5 | -1.111 | 3.223 | 4.769 |
| | (3.741) | (5.105) | (6.102) |
| 6 | 1.998 | -4.227 | -2.845 |
| | (3.953) | (5.197) | (5.475) |
| 7 | -0.423 | -10.58 | -5.510 |
| | (3.699) | (5.833) | (5.346) |
| Insurance group dummy | 1.842 | 5.965* | 3.738 |
| | (2.321) | (2.674) | (3.771) |
| Logged household income | -0.304 | -0.506 | -2.106 |
| | (2.292) | (2.287) | (2.127) |
| Total number of children | -1.212 | -5.141 | 0.164 |
| | (3.018) | (3.242) | (3.115) |
| Number of sons | -8.945* | -1.790 | -9.200* |
| | (3.924) | (4.159) | (4.554) |
| Married | 4.850 | 5.437 | 0.431 |
| | (8.194) | (9.247) | (9.423) |
| Observations | 5,280 | 5,280 | 5,280 |

Note: The dependent variable is quarterly hazard of partial oophorectomy. Uninsured are used as baseline. Other covariates are full sets of quarter dummies and data year fixed-effects. Robust standard errors clustered at the birth cohort level are in parentheses. $^{**}, p < 0.01$; $^{*}, p < 0.05$.

Table A4: Difference-in-difference estimates $\hat{\rho}_q$ for myomectomy in nonswitching sample

| | (1) Labor Insurance | (2) Government Employee Insurance | (3) Farmer Insurance |
|---|---|---|---|
| Quarter to 45th birthday x Insurance group dummy ($\rho_q$) | | | |
| -10 | -2.707 | -13.42 | -13.21* |
| | (4.773) | (7.971) | (5.562) |
| -9 | -0.920 | -6.991 | 4.795 |
| | (4.202) | (8.056) | (8.625) |
| -8 | 1.841 | -7.324 | 7.179 |
| | (5.931) | (6.125) | (8.156) |
| -7 | -0.389 | 1.275 | 2.511 |
| | (5.059) | (7.940) | (6.294) |
| -6 | 0.540 | -18.75* | 14.35* |
| | (5.052) | (7.451) | (6.754) |
| -5 | 1.383 | -13.39 | -5.908 |
| | (6.076) | (7.015) | (5.798) |
| -4 | 6.662 | 2.396 | 4.048 |
| | (7.010) | (7.328) | (5.869) |
| -3 | -1.561 | -6.716 | 3.010 |
| | (5.944) | (7.130) | (5.723) |
| -2 | -2.097 | -3.403 | 2.261 |
| | (5.007) | (7.583) | (7.174) |
| -1 | 4.064 | -4.757 | 0.711 |
| | (4.142) | (7.650) | (7.501) |
| 0 | -10.04* | -18.03* | -9.618 |
| | (4.023) | (7.562) | (5.125) |
| 1 | -4.035 | -22.87** | 3.083 |
| | (4.356) | (6.532) | (6.545) |
| 2 | 5.007 | -1.012 | 3.958 |
| | (4.101) | (8.110) | (6.661) |
| 3 | -0.337 | -12.59 | 2.179 |
| | (4.635) | (7.817) | (5.598) |
| 4 | 1.259 | -14.63* | 6.333 |
| | (4.890) | (7.351) | (7.447) |
| 5 | -8.786 | -12.01 | 4.681 |
| | (4.864) | (7.539) | (5.937) |
| 6 | -5.069 | -4.082 | 7.939 |
| | (4.293) | (8.640) | (6.306) |
| 7 | -2.199 | -14.25* | -0.199 |
| | (5.436) | (6.991) | (6.915) |
| Insurance group dummy | 9.877** | 17.12** | -7.212* |
| | (2.325) | (3.442) | (3.313) |
| Logged household income | -1.722 | 2.319 | 3.010 |
| | (3.046) | (2.974) | (3.218) |
| Total number of children | -6.398 | -6.563 | -2.253 |
| | (4.462) | (4.613) | (4.037) |
| Number of sons | 2.239 | 9.824 | 1.919 |
| | (6.077) | (5.448) | (5.756) |
| Married | -5.427 | -1.203 | 4.644 |
| | (12.48) | (12.35) | (11.60) |
| Observations | 5,280 | 5,280 | 5,280 |

Note: The dependent variable is quarterly hazard of myomectomy. Uninsured are used as baseline. Other covariates are full sets of quarter dummies and data year fixed-effects. Robust standard errors clustered at the birth cohort level are in parentheses. $^{**}, p < 0.01$; $^{*}, p < 0.05$.

Table A5: Bunching-smoothing polynomial estimates $\hat{\rho}_q$ for hysterectomy in nonswitching sample

| Quarters to age 45 | (1) Uninsured | (2) Labor Insurance | (3) Government Employee Insurance | (4) Farmer Insurance |
|---|---|---|---|---|
| -18 | 14.61* | | | |
| | (6.95) | | | |
| -17 | 2.22 | | | |
| | (7.32) | | | |
| -16 | -10.15 | | | |
| | (7.40) | | | |
| -15 | -4.43 | 9.67 | | |
| | (7.73) | (7.33) | | |
| -14 | 6.90 | 13.16 | | |
| | (7.40) | (7.00) | | |
| -13 | -15.66 | 13.75 | | |
| | (8.70) | (8.18) | | |
| -12 | -9.19 | 8.27 | | |
| | (8.50) | (8.14) | | |
| -11 | 8.40 | 20.73* | 19.20 | |
| | (9.64) | (8.72) | (11.55) | |
| -10 | 1.27 | 27.13** | 18.82 | |
| | (8.82) | (9.36) | (13.07) | |
| -9 | -7.15 | 33.64** | 27.08 | 17.44 |
| | (10.26) | (8.70) | (15.16) | (12.73) |
| -8 | 9.67 | 28.55** | 16.82 | -17.75 |
| | (9.30) | (8.99) | (12.73) | (12.68) |
| -7 | 4.55 | 26.96** | 44.99** | 29.01* |
| | (7.95) | (8.24) | (16.03) | (12.63) |
| -6 | -4.76 | 55.91** | 22.92* | 26.97* |
| | (9.29) | (10.25) | (10.78) | (12.59) |
| -5 | -9.24 | 61.88** | 39.84* | 16.66 |
| | (9.11) | (10.45) | (16.09) | (12.55) |
| -4 | 4.75 | 44.50** | 55.15** | 17.69 |
| | (9.56) | (9.46) | (17.69) | (12.48) |
| -3 | -6.23 | 65.06** | 58.50** | 19.13 |
| | (10.70) | (10.77) | (15.43) | (12.41) |
| -2 | -0.39 | 91.44** | 86.19** | 23.41 |
| | (9.72) | (10.60) | (18.09) | (12.34) |
| -1 | 11.72 | 201.20** | 187.31** | 68.64** |
| | (10.25) | (17.53) | (22.06) | (12.29) |
| 0 | 0.69 | -47.24** | -40.39** | -27.49* |
| | (10.68) | (7.99) | (11.31) | (12.20) |
| 1 | -1.65 | -20.55* | -28.25* | -19.43 |
| | (10.44) | (9.11) | (12.27) | (12.12) |
| 2 | 9.94 | 0.42 | 0.20 | 7.78 |
| | (11.07) | (8.79) | (11.63) | (12.04) |
| 3 | 3.71 | -16.17* | | |
| | (9.55) | (6.98) | | |
| 4 | 6.80 | -18.57* | | |
| | (10.86) | (8.66) | | |
| 5 | 13.15 | -10.05 | | |
| | (10.45) | (8.11) | | |
| 6 | 11.91 | | | |
| | (10.50) | | | |
| Optimal bounds ($q_L$ , $q_U$) | (-18, 6) | (-15, 5) | (-11, 2) | (-9, 2) |
| Estimated inducement effect | – | 4,842 | 756 | 280 |
| Estimated timing effect | – | 722 | 87 | 60 |
| Observations | 4,483 | 4,498 | 4,474 | 4,481 |

Notes: Robust standard errors clustered at the birth cohort level are in parentheses; $^{**}, p < 0.01$; $^{*}, p < 0.05$.

Table A6: Bunching-smoothing polynomial estimates $\hat{\rho}_q$ for total oophorectomy in nonswitching sample

| Quarters to age 45 | (1) Uninsured | (2) Labor Insurance | (3) Government Employee Insurance | (4) Farmer Insurance |
|---|---|---|---|---|
| -9 | 3.08 | -0.87 | 5.01 | 7.47 |
| | (2.94) | (1.66) | (3.52) | (5.33) |
| -8 | 1.59 | -1.28 | 5.22 | 5.62 |
| | (2.40) | (1.82) | (3.92) | (5.32) |
| -7 | 1.76 | -1.50 | -4.09 | -0.34 |
| | (2.74) | (2.18) | (2.94) | (5.32) |
| -6 | -0.15 | 0.01 | -4.83 | 1.68 |
| | (2.74) | (2.37) | (3.02) | (5.32) |
| -5 | -4.42 | -0.61 | -4.17 | 11.56* |
| | (2.87) | (2.45) | (3.02) | (5.32) |
| -4 | -3.76 | -1.59 | -1.33 | 4.46 |
| | (2.70) | (2.34) | (4.07) | (5.31) |
| -3 | -0.41 | -1.66 | 1.48 | -4.95 |
| | (3.35) | (2.51) | (4.22) | (5.29) |
| -2 | -2.69 | -0.92 | 6.53 | 1.92 |
| | (3.26) | (2.81) | (5.35) | (5.27) |
| -1 | -1.73 | 4.44 | 4.73 | -5.21 |
| | (4.08) | (3.60) | (4.66) | (5.25) |
| 0 | -3.98 | -6.80** | -4.82 | -4.84 |
| | (3.07) | (2.50) | (4.65) | (5.21) |
| 1 | -3.93 | -4.71 | -9.12** | -0.82 |
| | (3.25) | (3.01) | (3.31) | (5.18) |
| 2 | 0.14 | -4.13 | -1.19 | 3.72 |
| | (4.06) | (3.48) | (4.90) | (5.13) |
| 3 | -6.52 | -7.48* | | -6.50 |
| | (3.99) | (2.99) | | (5.09) |
| 4 | | -6.00 | | |
| | | (3.40) | | |
| 5 | | -4.17 | | |
| | | (3.48) | | |
| 6 | | -3.81 | | |
| | | (4.44) | | |
| 7 | | -1.36 | | |
| | | (4.76) | | |
| 8 | | -4.62 | | |
| | | (4.13) | | |
| 9 | | 1.39 | | |
| | | (4.44) | | |
| 10 | | -1.61 | | |
| | | (4.54) | | |
| 11 | | -5.60 | | |
| | | (4.23) | | |
| Optimal bounds ($q_L$, $q_U$) | (-9, 3) | (-9, 11) | (-9, 2) | (-9, 3) |
| Observations | 4,483 | 4,498 | 4,474 | 4,481 |

Note: The dependent variable is quarterly hazard of total oophorectomy. The covariates are 6th order polynomial terms of quarterly ages. Robust standard errors clustered at the birth cohort level are in parentheses. $^{**}, p < 0.01$; $^{*}, p < 0.05$.

Table A7: Bunching-smoothing polynomial estimates $\hat{\rho}_q$ for partial oophorectomy in nonswitching sample

| Quarters to age 45 | (1) Uninsured | (2) Labor Insurance | (3) Government Employee Insurance | (4) Farmer Insurance |
|---|---|---|---|---|
| -18 | | | | -3.85 |
| | | | | (6.33) |
| -17 | | | | -6.23 |
| | | | | (6.46) |
| -16 | | | | -5.07 |
| | | | | (6.57) |
| -15 | | | | -9.10 |
| | | | | (6.66) |
| -14 | | | | 14.51* |
| | | | | (6.73) |
| -13 | | | | -0.60 |
| | | | | (6.78) |
| -12 | | | | -8.77 |
| | | | | (6.80) |
| -11 | | | | -7.55 |
| | | | | (6.80) |
| -10 | | | | -9.55 |
| | | | | (6.78) |
| -9 | 0.65 | 1.61 | 1.64 | -4.08 |
| | (3.58) | (2.77) | (5.58) | (6.73) |
| -8 | -3.93 | -1.99 | 2.71 | -5.27 |
| | (2.59) | (2.80) | (4.73) | (6.66) |
| -7 | 0.51 | -2.48 | 6.71 | -1.56 |
| | (3.29) | (2.43) | (6.35) | (6.57) |
| -6 | 0.44 | 3.83 | 1.87 | 5.35 |
| | (3.67) | (3.10) | (5.77) | (6.46) |
| -5 | 0.62 | 1.81 | -4.57 | 1.08 |
| | (2.92) | (2.49) | (4.53) | (6.34) |
| -4 | -0.29 | 1.15 | 3.16 | -4.83 |
| | (3.22) | (2.65) | (5.39) | (6.19) |
| -3 | -1.77 | 1.15 | 1.89 | -10.57 |
| | (2.80) | (2.93) | (5.27) | (6.04) |
| -2 | 6.49* | 3.04 | 2.10 | 1.65 |
| | (2.86) | (2.77) | (5.41) | (5.88) |
| -1 | -0.35 | 0.78 | 9.16 | -1.66 |
| | (2.87) | (2.46) | (5.99) | (5.71) |
| 0 | -1.40 | 0.36 | -3.76 | 1.07 |
| | (2.90) | (2.80) | (4.90) | (5.54) |
| 1 | 1.94 | -1.67 | -1.32 | -3.70 |
| | (3.18) | (2.61) | (5.05) | (5.38) |
| 2 | 2.71 | 0.44 | 1.11 | -2.45 |
| | (3.14) | (2.77) | (4.59) | (5.21) |
| 3 | -1.38 | 1.33 | -3.48 | 2.50 |
| | (2.40) | (2.65) | (3.94) | (5.06) |
| 4 | | | 3.63 | -3.60 |
| | | | (5.18) | (4.91) |
| 5 | | | 9.26 | 7.68 |
| | | | (5.45) | (4.79) |
| Optimal bounds ($q_L$, $q_U$) | (-9, 3) | (-9, 3) | (-9, 5) | (-24, 5) |
| Observations | 4,483 | 4,498 | 4,474 | 4,481 |

Note: The dependent variable is quarterly hazard of partial oophorectomy. The covariates are 5th order polynomial terms of quarterly ages. For brevity, we only present estimates of q between -18 and 5. Robust standard errors clustered at the birth cohort level are in parentheses. $^{**}, p < 0.01$; $^{*}, p < 0.05$.

Table A8: Bunching-smoothing polynomial estimates $\hat{\rho}_q$ for myomectomy in nonswitching sample

| Quarters to age 45 | (1) Uninsured | (2) Labor Insurance | (3) Government Employee Insurance | (4) Farmer Insurance |
|---|---|---|---|---|
| -14 | -4.53 | | | 6.63 |
| | (4.20) | | | (6.34) |
| -13 | -0.40 | | | -9.84 |
| | (4.23) | | | (6.38) |
| -12 | -2.10 | | | 8.03 |
| | (4.52) | | | (6.40) |
| -11 | 4.50 | | | -9.11 |
| | (4.39) | | | (6.39) |
| -10 | -0.38 | | | 2.57 |
| | (4.28) | | | (6.38) |
| -9 | 1.25 | | | -17.30** |
| | (4.59) | | | (6.35) |
| -8 | -3.16 | -1.95 | -7.71 | -0.55 |
| | (3.59) | (3.62) | (6.72) | (6.30) |
| -7 | -0.36 | 1.94 | -3.52 | 2.80 |
| | (3.56) | (3.61) | (5.25) | (6.24) |
| -6 | -0.54 | 0.81 | 4.42 | -5.20 |
| | (4.12) | (3.83) | (7.32) | (6.16) |
| -5 | 3.13 | 4.84 | -10.47 | 9.52 |
| | (3.88) | (3.60) | (6.30) | (6.07) |
| -4 | -0.50 | 1.61 | -6.19 | -11.77* |
| | (4.24) | (3.91) | (5.87) | (5.98) |
| -3 | -4.23 | 0.89 | 3.47 | -7.51 |
| | (3.88) | (3.80) | (5.98) | (5.86) |
| -2 | -1.87 | -3.22 | 0.35 | -4.83 |
| | (3.72) | (3.42) | (6.76) | (5.75) |
| -1 | 0.32 | 0.79 | 3.29 | -2.12 |
| | (3.93) | (3.45) | (6.17) | (5.63) |
| 0 | -0.30 | 4.67 | 2.41 | -3.23 |
| | (3.52) | (3.88) | (6.60) | (5.51) |
| 1 | 3.59 | -1.99 | -4.73 | -9.74 |
| | (3.65) | (3.34) | (5.83) | (5.39) |
| 2 | 2.20 | 0.79 | -11.09* | -1.75 |
| | (3.40) | (3.33) | (4.89) | (5.28) |
| 3 | -5.59 | 3.72 | 3.48 | -2.84 |
| | (2.95) | (3.49) | (6.44) | (5.16) |
| 4 | | 1.03 | -3.73 | |
| | | (3.35) | (6.29) | |
| 5 | | 4.75 | -1.58 | |
| | | (3.58) | (5.87) | |
| 6 | | -1.98 | 0.64 | |
| | | (3.26) | (6.91) | |
| 7 | | 2.58 | 10.05 | |
| | | (3.23) | (6.62) | |
| 8 | | 0.45 | -1.29 | |
| | | (3.30) | (5.79) | |
| 9 | | -6.65* | 10.56 | |
| | | (2.75) | (7.31) | |
| Optimal bounds ($q_L$, $q_U$) | (-18 3) | (-8, 9) | (-8, 9) | (-22, 3) |
| Observations | 4,483 | 4,498 | 4,474 | 4,481 |

Note: The dependent variable is quarterly hazard of myomectomy. The covariates are 5th order polynomial terms of quarterly ages. For brevity, we only present estimates of q between -14 and 9. Robust standard errors clustered at the birth cohort level are in parentheses. $^{**}, p < 0.01$; $^{*}, p < 0.05$.

Table A9: Difference-in-difference estimates $\hat{\rho}_q$ for hysterectomy in general sample

| | (1) Labor Insurance | (2) Government Employee Insurance | (3) Farmer Insurance |
|---|---|---|---|
| Quarter to 45th birthday x Insurance group dummy ($\rho_q$ ) | | | |
| -10 | 30.77** | 18.61 | 12.61 |
| | (6.452) | (12.03) | (13.28) |
| -9 | 45.51** | 41.27** | 38.51** |
| | (6.228) | (12.50) | (14.23) |
| -8 | 23.36** | 11.62 | -10.93 |
| | (7.672) | (11.18) | (12.51) |
| -7 | 35.16** | 48.62** | 30.80* |
| | (6.353) | (14.56) | (13.81) |
| -6 | 49.09** | 19.10 | 19.14 |
| | (7.600) | (10.12) | (14.81) |
| -5 | 71.88** | 45.71** | 38.61** |
| | (6.571) | (12.85) | (12.82) |
| -4 | 41.86** | 57.94** | 19.41 |
| | (7.140) | (15.60) | (13.66) |
| -3 | 70.79** | 66.97** | 26.85* |
| | (9.377) | (12.11) | (11.16) |
| -2 | 84.47** | 85.95** | 34.00* |
| | (8.862) | (14.72) | (14.48) |
| -1 | 180.6** | 164.5** | 37.67** |
| | (12.10) | (19.31) | (13.45) |
| 0 | -41.08** | -35.35** | -28.57* |
| | (7.792) | (11.27) | (13.10) |
| 1 | -20.09* | -22.88 | -14.39 |
| | (7.979) | (13.02) | (14.03) |
| 2 | -12.46 | -4.111 | -1.821 |
| | (7.720) | (10.75) | (14.54) |
| 3 | -20.43** | 3.021 | -3.919 |
| | (7.122) | (12.76) | (14.14) |
| 4 | -22.43** | -14.00 | 1.716 |
| | (6.908) | (12.47) | (12.58) |
| 5 | -17.43* | 0.313 | -6.784 |
| | (7.353) | (13.60) | (13.22) |
| 6 | -14.53 | -11.94 | -0.213 |
| | (9.009) | (10.98) | (14.23) |
| 7 | -3.877 | 5.524 | -15.94 |
| | (6.551) | (13.75) | (12.06) |
| Insurance group dummy | 10.53** | -19.27** | 35.96** |
| | (3.189) | (3.888) | (5.471) |
| Logged household income | -13.98** | -10.13* | -23.37** |
| | (4.740) | (4.198) | (5.643) |
| Total number of children | -20.83** | -18.02* | -19.74** |
| | (7.698) | (7.790) | (6.969) |
| Number of sons | 6.555 | 2.188 | -0.166 |
| | (10.12) | (9.886) | (8.980) |
| Married | 33.16* | 42.33* | 20.06 |
| | (15.92) | (18.37) | (18.62) |
| Observations | 5,280 | 5,280 | 5,280 |

Note: The dependent variable is quarterly hazard of hysterectomy. Uninsured are used as baseline. Other covariates are full sets of quarter dummies and data year fixed-effects. Robust standard errors clustered at the birth cohort level are in parentheses. $^{**}, p < 0.01$; $^{*}, p < 0.05$.

Table A10: Difference-in-difference estimates $\hat{\rho}_q$ for total oophorectomy in general sample

| | (1) Labor Insurance | (2) Government Employee Insurance | (3) Farmer Insurance |
|---|---|---|---|
| Quarter to 45th birthday x Insurance group dummy ($\rho_q$) | | | |
| -10 | 0.117 | 0.323 | -0.0534 |
| | (2.235) | (3.277) | (3.908) |
| -9 | -1.196 | 7.012 | 4.218 |
| | (2.421) | (4.726) | (4.828) |
| -8 | -1.979 | 4.016 | 3.181 |
| | (2.470) | (4.459) | (4.852) |
| -7 | -0.0735 | -2.244 | -0.151 |
| | (2.395) | (3.636) | (4.194) |
| -6 | -0.866 | -4.103 | -2.317 |
| | (2.840) | (4.538) | (4.984) |
| -5 | 2.744 | 2.801 | 9.398 |
| | (2.962) | (3.530) | (5.461) |
| -4 | 2.438 | 5.172 | 1.506 |
| | (2.789) | (5.145) | (5.170) |
| -3 | -0.178 | 2.336 | -5.931 |
| | (3.296) | (5.112) | (4.535) |
| -2 | 3.192 | 13.41* | 0.729 |
| | (3.527) | (6.694) | (4.541) |
| -1 | 6.570 | 10.55* | -6.958 |
| | (3.900) | (4.374) | (4.917) |
| 0 | -2.120 | -1.610 | -5.461 |
| | (3.461) | (6.117) | (6.323) |
| 1 | -2.723 | -5.318 | -0.0806 |
| | (3.555) | (4.872) | (5.717) |
| 2 | -7.557 | -1.015 | -3.826 |
| | (4.602) | (6.252) | (6.089) |
| 3 | -5.766 | 6.469 | -7.940 |
| | (4.197) | (5.606) | (5.453) |
| 4 | -10.58* | -0.807 | -6.592 |
| | (4.784) | (6.253) | (6.753) |
| 5 | -9.506 | -0.0366 | -11.26 |
| | (4.917) | (6.660) | (7.430) |
| 6 | -12.25** | -6.582 | -8.896 |
| | (4.650) | (7.214) | (7.253) |
| 7 | -8.147 | 1.831 | -10.26 |
| | (5.982) | (7.252) | (6.934) |
| Insurance group dummy | -4.941** | -6.798** | 4.602* |
| | (1.003) | (1.335) | (1.960) |
| Logged household income | 5.588** | 3.117 | 4.691 |
| | (2.065) | (1.930) | (2.775) |
| Total number of children | -34.38** | -29.60** | -26.38** |
| | (3.756) | (3.692) | (3.215) |
| Number of sons | -14.77** | -13.87** | -3.313 |
| | (4.417) | (4.402) | (3.368) |
| Married | 23.81** | 36.69** | 34.54** |
| | (8.901) | (7.815) | (8.594) |
| Observations | 5,280 | 5,280 | 5,280 |

Note: The dependent variable is quarterly hazard of total oophorectomy. Uninsured are used as baseline. Other covariates are full sets of quarter dummies and data year fixed-effects. Robust standard errors clustered at the birth cohort level are in parentheses. $^{**}, p < 0.01$; $^{*}, p < 0.05$.

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Table A11: Difference-in-difference estimates $\hat{\rho}_q$ for partial oophorectomy in general sample

| | (1) Labor Insurance | (2) Government Employee Insurance | (3) Farmer Insurance |
|---|---|---|---|
| Quarter to 45th birthday x Insurance group dummy ($\rho_q$) | | | |
| -10 | 4.772 | 1.584 | -3.888 |
| | (3.216) | (5.970) | (5.010) |
| -9 | 3.867 | -0.270 | 1.442 |
| | (2.649) | (5.348) | (5.969) |
| -8 | 2.405 | 6.499 | -0.544 |
| | (3.360) | (5.342) | (4.816) |
| -7 | 1.866 | 7.671 | 2.814 |
| | (3.068) | (5.941) | (5.416) |
| -6 | 4.936 | 4.734 | 8.155 |
| | (3.428) | (7.231) | (5.716) |
| -5 | 2.352 | -3.932 | -0.387 |
| | (3.037) | (5.189) | (5.586) |
| -4 | 0.565 | 2.040 | -6.526 |
| | (2.870) | (5.581) | (5.670) |
| -3 | 8.421** | 5.423 | -3.199 |
| | (3.039) | (5.519) | (5.272) |
| -2 | 1.012 | -4.386 | -0.177 |
| | (3.066) | (6.006) | (5.965) |
| -1 | 2.420 | 9.904 | 0.402 |
| | (3.032) | (5.690) | (5.275) |
| 0 | 3.130 | -5.179 | 5.597 |
| | (2.914) | (4.716) | (5.452) |
| 1 | -4.414 | -5.585 | -2.095 |
| | (3.192) | (5.440) | (5.394) |
| 2 | 0.294 | 2.279 | 0.658 |
| | (3.108) | (7.578) | (5.524) |
| 3 | 4.215 | -1.124 | 4.391 |
| | (2.953) | (4.703) | (5.059) |
| 4 | -0.122 | -2.535 | -2.095 |
| | (2.506) | (5.369) | (4.201) |
| 5 | 1.832 | 6.290 | 11.47* |
| | (3.137) | (4.953) | (5.731) |
| 6 | 0.615 | -6.217 | -1.340 |
| | (2.809) | (4.790) | (5.338) |
| 7 | 1.809 | -5.028 | 1.545 |
| | (3.049) | (5.742) | (4.743) |
| Insurance group dummy | 0.759 | 3.966 | 0.565 |
| | (1.728) | (2.400) | (3.228) |
| Logged household income | -0.606 | -0.816 | -2.803 |
| | (1.879) | (1.985) | (2.095) |
| Total number of children | -2.857 | -4.910 | -1.648 |
| | (2.863) | (3.007) | (2.750) |
| Number of sons | -6.615 | -2.940 | -8.579* |
| | (3.721) | (3.897) | (3.585) |
| Married | 4.684 | 8.703 | 5.615 |
| | (6.874) | (8.669) | (8.506) |
| Observations | 5,280 | 5,280 | 5,280 |

Note: The dependent variable is quarterly hazard of partial oophorectomy. Uninsured are used as baseline. Other covariates are full sets of quarter dummies and data year fixed-effects. Robust standard errors clustered at the birth cohort level are in parentheses. $^{**}, p < 0.01$; $^{*}, p < 0.05$.

Table A12: Difference-in-difference estimates $\hat{\rho}_q$ for myomectomy in general sample

| | (1) Labor Insurance | (2) Government Employee Insurance | (3) Farmer Insurance |
|---|---|---|---|
| Quarter to 45th birthday x Insurance group dummy ($\rho_q$) | | | |
| -10 | 0.618 | -3.451 | -14.19** |
| | (3.813) | (6.864) | (4.487) |
| -9 | 4.566 | 0.550 | 5.865 |
| | (2.933) | (7.664) | (7.189) |
| -8 | -0.346 | 1.986 | 0.291 |
| | (4.425) | (5.976) | (7.137) |
| -7 | -2.572 | 5.536 | 0.0176 |
| | (4.165) | (7.402) | (5.991) |
| -6 | 0.598 | -10.35 | 7.467 |
| | (3.303) | (6.384) | (5.427) |
| -5 | 5.221 | -0.481 | -6.664 |
| | (4.626) | (5.535) | (5.364) |
| -4 | 9.053 | 13.14 | -3.094 |
| | (4.841) | (6.652) | (4.398) |
| -3 | 2.962 | 4.995 | 0.701 |
| | (4.212) | (7.125) | (5.176) |
| -2 | 0.731 | 8.834 | -0.807 |
| | (3.945) | (7.230) | (6.463) |
| -1 | 4.472 | 7.988 | -7.022 |
| | (3.725) | (7.177) | (6.016) |
| 0 | -6.444* | -1.536 | -9.801* |
| | (3.067) | (6.292) | (4.753) |
| 1 | 3.126 | -2.779 | -3.409 |
| | (3.677) | (5.794) | (5.673) |
| 2 | 7.406* | 14.29* | -2.699 |
| | (2.958) | (6.657) | (5.236) |
| 3 | 2.833 | 1.625 | -3.860 |
| | (3.400) | (6.892) | (4.635) |
| 4 | 4.923 | 2.770 | -1.352 |
| | (4.106) | (6.320) | (6.087) |
| 5 | -2.012 | 4.152 | 1.516 |
| | (4.017) | (6.721) | (5.244) |
| 6 | 2.865 | 18.38* | 4.581 |
| | (3.435) | (8.541) | (6.406) |
| 7 | 4.608 | 7.466 | -1.436 |
| | (4.388) | (6.397) | (6.129) |
| Insurance group dummy | 9.021** | 15.55** | -5.065 |
| | (1.748) | (3.191) | (3.140) |
| Logged household income | -1.971 | 1.893 | 1.746 |
| | (2.367) | (2.669) | (2.589) |
| Total number of children | -4.862 | -5.062 | -2.254 |
| | (3.850) | (4.027) | (3.447) |
| Number of sons | -1.996 | 5.733 | -2.839 |
| | (5.532) | (4.813) | (4.556) |
| Married | -2.160 | 1.764 | 4.204 |
| | (9.922) | (10.83) | (11.20) |
| Observations | 5,280 | 5,280 | 5,280 |

Note: The dependent variable is quarterly hazard of myomectomy. Uninsured are used as baseline. Other covariates are full sets of quarter dummies and data year fixed-effects. Robust standard errors clustered at the birth cohort level are in parentheses. $^{**}, p < 0.01$; $^{*}, p < 0.05$.

Table A13: Difference-in-difference estimates $\hat{\rho}_q$ for hysterectomy in balanced sample

| | (1) Labor Insurance | (2) Government Employee Insurance | (3) Farmer Insurance |
|---|---|---|---|
| Quarter to 45th birthday x Insurance group dummy ($\rho_q$) | | | |
| -10 | 51.91** | 55.68* | 43.84 |
| | (12.14) | (25.78) | (28.55) |
| -9 | 57.93** | 75.65* | 43.39 |
| | (15.57) | (32.79) | (33.94) |
| -8 | 42.49* | 31.02 | -3.186 |
| | (19.52) | (19.82) | (29.17) |
| -7 | 30.30** | 59.60* | 33.97 |
| | (10.15) | (23.33) | (26.26) |
| -6 | 79.01** | 30.08 | 57.59* |
| | (21.04) | (17.78) | (20.60) |
| -5 | 84.01** | 51.24 | 38.06 |
| | (18.02) | (33.14) | (31.29) |
| -4 | 47.56** | 64.20 | 52.19 |
| | (12.83) | (37.15) | (26.74) |
| -3 | 80.12** | 75.88** | 57.44** |
| | (16.24) | (20.95) | (17.49) |
| -2 | 75.21** | 117.0** | 23.98 |
| | (18.13) | (31.53) | (24.07) |
| -1 | 195.4** | 207.6** | 63.14* |
| | (26.08) | (39.41) | (28.38) |
| 0 | -55.98** | -10.68 | -11.75 |
| | (17.02) | (21.16) | (20.95) |
| 1 | -18.70 | -10.48 | 13.71 |
| | (20.57) | (29.62) | (33.18) |
| 2 | 5.616 | -4.302 | 23.17 |
| | (15.24) | (28.45) | (21.30) |
| 3 | -28.53 | -19.56 | 16.28 |
| | (16.10) | (24.81) | (35.00) |
| 4 | -27.86 | -14.57 | 28.13 |
| | (19.00) | (25.20) | (25.03) |
| 5 | -8.301 | 18.70 | 19.33 |
| | (11.78) | (28.23) | (20.58) |
| 6 | -13.92 | 8.849 | 27.29 |
| | (26.70) | (35.25) | (31.42) |
| 7 | -2.159 | 5.176 | 25.24 |
| | (17.98) | (30.72) | (42.76) |
| Insurance group dummy | -10.58 | -38.91** | 38.13** |
| | (8.762) | (10.71) | (11.26) |
| Logged household income | -39.00** | -0.555 | -16.18 |
| | (8.617) | (8.792) | (12.62) |
| Total number of children | -80.07** | -55.39** | -43.98 |
| | (17.97) | (18.93) | (21.23) |
| Number of sons | 1.063 | 22.42 | -5.374 |
| | (24.54) | (20.95) | (23.45) |
| Married | 41.89 | 46.65 | 6.762 |
| | (30.84) | (28.45) | (54.48) |
| Observations | 1,748 | 1,748 | 1,748 |

Note: The dependent variable is quarterly hazard of hysterectomy. Uninsured are used as baseline. Other covariates are full sets of quarter dummies and data year fixed-effects. Robust standard errors clustered at the birth cohort level are in parentheses. $^{**}, p < 0.01$; $^{*}, p < 0.05$.

Table A14: Difference-in-difference estimates $\hat{\rho}_q$ for total oophorectomy in balanced sample

| | (1) Labor Insurance | (2) Government Employee Insurance | (3) Farmer Insurance |
|---|---|---|---|
| Quarter to 45th birthday x Insurance group dummy ($\rho_q$) | | | |
| -10 | -5.650 | 11.18 | 3.675 |
| | (4.556) | (7.272) | (7.512) |
| -9 | -1.475 | 3.704 | 4.138 |
| | (5.160) | (6.279) | (10.83) |
| -8 | -3.832 | 10.32 | -0.151 |
| | (4.706) | (8.231) | (7.744) |
| -7 | -9.690 | -7.723 | -9.808 |
| | (5.668) | (6.135) | (7.193) |
| -6 | -4.681 | 7.627 | -3.881 |
| | (5.080) | (9.442) | (6.421) |
| -5 | 1.070 | -0.637 | 1.311 |
| | (6.337) | (4.667) | (6.602) |
| -4 | -1.000 | 5.319 | 4.716 |
| | (4.953) | (7.819) | (7.664) |
| -3 | -5.007 | -2.793 | -12.08* |
| | (4.258) | (5.841) | (5.412) |
| -2 | -7.218 | -0.791 | -1.340 |
| | (6.962) | (8.485) | (8.490) |
| -1 | 4.848 | 7.717 | -5.884 |
| | (4.222) | (6.465) | (7.117) |
| 0 | -10.81* | -0.572 | -0.843 |
| | (5.154) | (9.595) | (8.885) |
| 1 | 0.737 | -7.652 | 15.01 |
| | (5.059) | (7.577) | (8.964) |
| 2 | -9.098 | -7.208 | 0.633 |
| | (5.890) | (10.42) | (9.106) |
| 3 | -4.432 | 8.154 | -0.662 |
| | (6.401) | (9.199) | (7.568) |
| 4 | -15.97* | -7.762 | -5.511 |
| | (6.032) | (8.568) | (6.919) |
| 5 | 1.533 | 7.671 | 5.541 |
| | (5.693) | (10.23) | (11.37) |
| 6 | -8.633 | -2.236 | -1.734 |
| | (7.083) | (11.18) | (10.39) |
| 7 | -12.35 | 15.11 | -14.61 |
| | (8.378) | (14.96) | (11.09) |
| Insurance group dummy | -1.907 | -5.519 | 7.219 |
| | (1.160) | (3.466) | (4.345) |
| Logged household income | -4.070 | 3.679 | 0.119 |
| | (3.843) | (3.079) | (4.373) |
| Total number of children | -12.42** | -12.99* | -15.59* |
| | (4.144) | (4.541) | (5.597) |
| Number of sons | -12.83 | -6.228 | 1.723 |
| | (6.615) | (8.517) | (8.205) |
| Married | 10.05 | 0.255 | 21.29 |
| | (11.50) | (13.41) | (15.78) |
| Observations | 1,748 | 1,748 | 1,748 |

Note: The dependent variable is quarterly hazard of total oophorectomy. Uninsured are used as baseline. Other covariates are full sets of quarter dummies and data year fixed-effects. Robust standard errors clustered at the birth cohort level are in parentheses. $^{**}, p < 0.01$; $^{*}, p < 0.05$.

Table A15: Difference-in-difference estimates $\hat{\rho}_q$ for partial oophorectomy in balanced sample

| | (1) Labor Insurance | (2) Government Employee Insurance | (3) Farmer Insurance |
|---|---|---|---|
| Quarter to 45th birthday x Insurance group dummy ($\rho_q$) | | | |
| -10 | -7.409 | -13.94 | -4.319 |
| | (4.558) | (9.426) | (6.439) |
| -9 | -5.338 | -14.31 | -0.124 |
| | (6.572) | (8.882) | (12.37) |
| -8 | -5.177 | 2.971 | 3.346 |
| | (5.253) | (12.40) | (8.457) |
| -7 | -13.01 | -5.867 | 1.374 |
| | (6.762) | (11.59) | (9.889) |
| -6 | -3.400 | -0.0364 | 6.498 |
| | (8.941) | (11.75) | (11.16) |
| -5 | -13.98 | -22.62** | 13.76 |
| | (7.851) | (7.807) | (12.20) |
| -4 | -6.259 | 8.917 | 0.0910 |
| | (6.168) | (11.78) | (9.774) |
| -3 | -5.817 | -7.127 | -16.50 |
| | (6.035) | (14.25) | (10.21) |
| -2 | -20.32* | -21.60* | -21.24 |
| | (8.300) | (8.230) | (10.45) |
| -1 | -5.937 | 0.665 | -5.350 |
| | (6.214) | (9.347) | (10.68) |
| 0 | -6.426 | 3.375 | 4.791 |
| | (6.251) | (12.61) | (7.412) |
| 1 | -15.82 | -25.86* | -17.79 |
| | (8.133) | (11.82) | (9.731) |
| 2 | -10.52 | -23.71 | -3.099 |
| | (6.362) | (12.23) | (12.28) |
| 3 | -7.768 | -11.71 | 12.33 |
| | (6.865) | (9.434) | (11.43) |
| 4 | -8.221 | 4.308 | -2.026 |
| | (6.545) | (11.30) | (10.11) |
| 5 | -7.120 | 8.433 | 11.56 |
| | (6.906) | (10.71) | (11.40) |
| 6 | -5.474 | -18.62 | -7.881 |
| | (7.057) | (12.84) | (10.50) |
| 7 | -10.26 | -31.49** | -7.237 |
| | (8.033) | (8.895) | (10.51) |
| Insurance group dummy | 9.160* | 15.91* | 5.960 |
| | (3.273) | (5.630) | (4.264) |
| Logged household income | -12.26** | -3.915 | -2.945 |
| | (3.643) | (5.607) | (4.119) |
| Total number of children | 12.10 | 1.957 | 5.194 |
| | (7.683) | (9.661) | (7.676) |
| Number of sons | -15.27 | 5.649 | -16.41 |
| | (12.59) | (11.17) | (11.94) |
| Married | -21.84 | -20.85 | -21.22 |
| | (17.26) | (17.00) | (17.33) |
| Observations | 1,748 | 1,748 | 1,748 |

Note: The dependent variable is quarterly hazard of partial oophorectomy. Uninsured are used as baseline. Other covariates are full sets of quarter dummies and data year fixed-effects. Robust standard errors clustered at the birth cohort level are in parentheses. $^{**}, p < 0.01$; $^{*}, p < 0.05$.

Table A16: Difference-in-difference estimates $\hat{\rho}_q$ for myomectomy in balanced sample

| | (1) Labor Insurance | (2) Government Employee Insurance | (3) Farmer Insurance |
|---|---|---|---|
| Quarter to 45th birthday x Insurance group dummy ($\rho_q$) | | | |
| -10 | 14.48 | -3.865 | -1.985 |
| | (7.250) | (10.85) | (7.843) |
| -9 | 4.051 | 7.061 | 4.020 |
| | (7.229) | (14.74) | (9.278) |
| -8 | 5.595 | 4.096 | 20.78 |
| | (7.256) | (9.837) | (11.56) |
| -7 | -4.243 | 22.07 | 5.355 |
| | (8.143) | (14.79) | (11.35) |
| -6 | 1.940 | 3.839 | 14.70 |
| | (7.386) | (10.65) | (12.71) |
| -5 | 5.760 | -8.830 | -8.254 |
| | (8.640) | (11.16) | (13.47) |
| -4 | -2.833 | 14.73 | -19.82* |
| | (9.166) | (10.46) | (9.442) |
| -3 | -7.076 | 1.873 | -4.594 |
| | (7.541) | (12.22) | (10.33) |
| -2 | -9.740 | 22.23 | 3.810 |
| | (6.781) | (16.96) | (12.96) |
| -1 | -1.070 | 5.050 | 7.194 |
| | (7.304) | (12.68) | (14.86) |
| 0 | -1.676 | 8.449 | -18.04 |
| | (8.232) | (11.57) | (10.39) |
| 1 | -9.163 | -2.584 | -5.473 |
| | (7.855) | (8.811) | (12.95) |
| 2 | 7.441 | 31.17 | 0.522 |
| | (7.450) | (16.05) | (11.02) |
| 3 | -3.469 | 12.59 | 2.930 |
| | (10.13) | (13.92) | (12.04) |
| 4 | 7.520 | 7.536 | -8.274 |
| | (8.144) | (14.60) | (10.58) |
| 5 | -10.11 | 23.52 | 5.543 |
| | (10.44) | (15.29) | (13.99) |
| 6 | -2.768 | 19.24 | 7.536 |
| | (7.453) | (17.51) | (13.03) |
| 7 | 3.457 | 26.40 | 13.84 |
| | (11.39) | (16.30) | (18.83) |
| Insurance group dummy | 9.804** | 13.90* | -9.394 |
| | (3.400) | (6.634) | (4.732) |
| Logged household income | -19.68** | 8.231 | -6.702 |
| | (5.614) | (5.565) | (4.978) |
| Total number of children | -12.08 | 8.602 | 13.89 |
| | (8.927) | (6.816) | (6.697) |
| Number of sons | 25.84* | 7.858 | -8.823 |
| | (11.73) | (10.61) | (8.445) |
| Married | 12.29 | -36.02 | -26.67 |
| | (19.62) | (19.98) | (18.91) |
| Observations | 1,748 | 1,748 | 1,748 |

Note: The dependent variable is quarterly hazard of myomectomy. Uninsured are used as baseline. Other covariates are full sets of quarter dummies and data year fixed-effects. Robust standard errors clustered at the birth cohort level are in parentheses. $^{**}, p < 0.01$; $^{*}, p < 0.05$.

Table A17: Bunching-smoothing polynomial estimates $\hat{\rho}_q$ for hysterectomy in general sample

| Quarters to age 45 | (1) Uninsured | (2) Labor Insurance | (3) Government Employee Insurance | (4) Farmer Insurance |
|---|---|---|---|---|
| -16 | -12.19 | | | |
| | (6.460) | | | |
| -15 | -4.250 | 7.065 | | |
| | (6.862) | (6.779) | | |
| -14 | -1.199 | 13.10 | | |
| | (6.271) | (7.628) | | |
| -13 | -12.39 | 15.49 | | |
| | (7.873) | (8.123) | | |
| -12 | -12.94 | 7.431 | | |
| | (7.535) | (8.214) | | |
| -11 | 1.618 | 20.44* | 17.34 | |
| | (7.939) | (8.449) | (11.76) | |
| -10 | -2.270 | 26.97** | 18.70 | |
| | (7.508) | (9.219) | (13.84) | |
| -9 | -15.01 | 29.40** | 28.02 | 17.84 |
| | (8.370) | (8.423) | (14.55) | (11.73) |
| -8 | 5.283 | 27.18** | 17.61 | -12.60 |
| | (8.138) | (8.455) | (12.56) | (11.69) |
| -7 | -6.594 | 27.76** | 42.70** | 19.12 |
| | (7.430) | (8.224) | (15.44) | (11.66) |
| -6 | 3.140 | 51.85** | 22.24* | 18.38 |
| | (9.094) | (9.447) | (10.72) | (11.62) |
| -5 | -11.30 | 60.90** | 34.21* | 24.91* |
| | (8.425) | (9.677) | (15.48) | (11.60) |
| -4 | -2.245 | 40.42** | 55.11** | 16.10 |
| | (9.002) | (8.923) | (16.82) | (11.54) |
| -3 | -8.338 | 64.51** | 58.94** | 18.00 |
| | (9.569) | (10.55) | (14.73) | (11.50) |
| -2 | 3.611 | 90.91** | 90.07** | 37.14** |
| | (8.968) | (10.29) | (18.29) | (11.46) |
| -1 | 18.67 | 204.7** | 185.4** | 55.96** |
| | (10.34) | (16.76) | (21.79) | (11.42) |
| 0 | -8.864 | -45.79** | -43.35** | -37.59** |
| | (9.030) | (7.549) | (11.64) | (11.35) |
| 1 | -4.724 | -20.11* | -26.97* | -17.92 |
| | (8.702) | (7.969) | (13.02) | (11.30) |
| 2 | 1.883 | -5.561 | -2.852 | 2.154 |
| | (9.664) | (8.004) | (12.23) | (11.24) |
| 3 | | -16.93* | 1.141 | |
| | | (6.963) | (13.21) | |
| 4 | | -18.19* | -15.96 | |
| | | (7.829) | (12.88) | |
| 5 | | -8.814 | 1.858 | |
| | | (7.400) | (14.20) | |
| 6 | | | -7.622 | |
| | | | (13.36) | |
| Optimal bounds ($q_L$, $q_U$) | (-16, 2) | (-15, 5) | (-11, 9) | (-9, 2) |
| Observations | 4,483 | 4,498 | 4,474 | 4,481 |

Note: The dependent variable is quarterly hazard of hysterectomy. The covariates are 5th order polynomial terms of quarterly ages. For brevity, we only present estimates of q between -16 and 6. Robust standard errors clustered at the birth cohort level are in parentheses. $^{**}, p < 0.01$; $^{*}, p < 0.05$.

Table A18: Bunching-smoothing polynomial estimates $\hat{\rho}_q$ for total oophorectomy in general sample

| Quarters to age 45 | (1) Uninsured | (2) Labor Insurance | (3) Government Employee Insurance | (4) Farmer Insurance |
|---|---|---|---|---|
| -7 | 0.35 | -0.95 | 3.61 | 3.61 |
| | (1.97) | (1.53) | (3.67) | (4.87) |
| -6 | -1.10 | -0.46 | -4.46 | -0.09 |
| | (2.05) | (2.10) | (2.83) | (4.87) |
| -5 | -0.27 | -0.01 | -5.26 | 0.10 |
| | (2.20) | (2.02) | (3.06) | (4.88) |
| -4 | -4.40* | -1.12 | -3.38 | 8.64 |
| | (2.15) | (1.96) | (3.28) | (4.88) |
| -3 | -4.53* | -1.49 | -1.53 | 1.40 |
| | (2.24) | (2.14) | (3.97) | (4.87) |
| -2 | -0.87 | 0.21 | 0.30 | -1.95 |
| | (2.84) | (2.27) | (4.18) | (4.86) |
| -1 | -4.47 | 0.27 | 8.37 | 0.98 |
| | (2.61) | (2.39) | (5.88) | (4.85) |
| 0 | -3.30 | 4.94 | 5.97 | -5.02 |
| | (3.17) | (3.09) | (4.61) | (4.84) |
| 1 | -4.00 | -3.95 | -6.43 | -4.26 |
| | (2.71) | (2.17) | (4.58) | (4.81) |
| 2 | -3.86 | -2.51 | -9.02** | 2.03 |
| | (2.70) | (2.50) | (3.34) | (4.78) |
| 3 | -0.93 | -3.63 | -2.43 | 1.95 |
| | (3.48) | (2.88) | (4.66) | (4.74) |
| 4 | -6.13* | -6.10* | | -5.43 |
| | (3.05) | (2.48) | | (4.71) |
| 5 | | -4.03 | | |
| | | (2.88) | | |
| 6 | | -2.92 | | |
| | | (2.92) | | |
| 7 | | -2.91 | | |
| | | (3.78) | | |
| Optimal bounds ($q_L$, $q_U$) | (-7, 4) | (-7, 7) | (-7, 3) | (-7, 4) |
| Observations | 4,483 | 4,498 | 4,474 | 4,481 |

Note: The dependent variable is quarterly hazard of total oophorectomy. The covariates are 6th order polynomial terms of quarterly ages. Robust standard errors clustered at the birth cohort level are in parentheses. $^{**}, p < 0.01$; $^{*}, p < 0.05$.

Table A19: Bunching-smoothing polynomial estimates $\hat{\rho}_q$ for partial oophorectomy in general sample

| Quarters to age 45 | (1) Uninsured | (2) Labor Insurance | (3) Government Employee Insurance | (4) Farmer Insurance |
|---|---|---|---|---|
| -13 | | | | 17.46** |
| | | | | (4.64) |
| -12 | | 0.09 | -5.59 | 1.81 |
| | | (2.70) | (4.92) | (4.66) |
| -11 | -3.85 | 0.61 | -4.05 | -4.72 |
| | (2.65) | (2.57) | (5.45) | (4.66) |
| -10 | 2.82 | -0.54 | -0.50 | -0.90 |
| | (2.91) | (2.62) | (4.79) | (4.66) |
| -9 | 0.36 | 2.97 | -1.45 | -1.80 |
| | (2.56) | (2.85) | (5.24) | (4.66) |
| -8 | -0.93 | 1.80 | -1.16 | 3.32 |
| | (2.73) | (2.62) | (5.41) | (4.65) |
| -7 | -1.33 | -2.08 | 0.51 | -1.69 |
| | (2.58) | (2.49) | (4.65) | (4.64) |
| -6 | -0.77 | -1.53 | 4.94 | 1.96 |
| | (2.63) | (2.38) | (6.20) | (4.62) |
| -5 | -0.83 | 3.53 | 1.19 | 9.51* |
| | (2.98) | (2.83) | (5.95) | (4.60) |
| -4 | 1.01 | 1.42 | -5.39 | 2.69 |
| | (2.54) | (2.46) | (4.47) | (4.58) |
| -3 | -0.21 | -0.45 | 1.82 | -2.23 |
| | (2.66) | (2.40) | (5.33) | (4.55) |
| -2 | -2.88 | 2.35 | 1.43 | -7.02 |
| | (2.41) | (2.65) | (5.56) | (4.51) |
| -1 | 2.65 | 2.31 | 0.30 | 4.78 |
| | (2.52) | (2.40) | (5.35) | (4.48) |
| 0 | -0.08 | -0.06 | 6.93 | 1.91 |
| | (2.41) | (2.34) | (5.90) | (4.45) |
| 1 | -1.58 | -0.62 | -4.92 | 3.34 |
| | (2.67) | (2.33) | (4.70) | (4.40) |
| 2 | 4.03 | -2.18 | -2.55 | -0.14 |
| | (2.63) | (2.47) | (4.92) | (4.37) |
| 3 | 2.07 | 0.15 | 0.53 | 3.16 |
| | (2.40) | (2.20) | (4.91) | (4.33) |
| 4 | | | -2.88 | 2.78 |
| | | | (4.28) | (4.29) |
| 5 | | | 1.65 | -0.67 |
| | | | (4.86) | (4.25) |
| 6 | | | 7.75 | 10.37* |
| | | | (5.19) | (4.21) |
| | (2.626) | (2.091) | (4.598) | (4.316) |
| Optimal bounds $(q_L, q_U)$ | (-11, 3) | (-12, 3) | (-12, 7) | (-12, 7) |
| Observations | 4,483 | 4,498 | 4,474 | 4,481 |

Note: The dependent variable is quarterly hazard of partial oophorectomy. The covariates are 5th order polynomial terms of quarterly ages. Robust standard errors clustered at the birth cohort level are in parentheses. $^{**}, p < 0.01$; $^{*}, p < 0.05$.

Table A20: Bunching-smoothing polynomial estimates $\hat{\rho}_q$ for myomectomy in general sample

| Quarters to age 45 | (1) Uninsured | (2) Labor Insurance | (3) Government Employee Insurance | (4) Farmer Insurance |
|---|---|---|---|---|
| -12 | -2.85 | | | 13.40* |
| | (3.34) | | | (5.23) |
| -11 | 2.22 | | | -1.31 |
| | (3.27) | | | (5.24) |
| -10 | -2.02 | | | 5.40 |
| | (3.53) | | | (5.23) |
| -9 | 2.20 | 3.10 | | -14.16** |
| | (3.56) | (3.61) | | (5.22) |
| -8 | -3.31 | 0.72 | -9.08 | 5.47 |
| | (2.80) | (3.18) | (6.51) | (5.21) |
| -7 | 1.08 | 0.23 | -1.13 | 4.78 |
| | (3.08) | (2.97) | (5.64) | (5.17) |
| -6 | 2.62 | -0.65 | 2.23 | 0.21 |
| | (3.29) | (3.47) | (6.91) | (5.14) |
| -5 | 4.56 | 3.78 | -10.83 | 10.85* |
| | (2.86) | (3.17) | (6.04) | (5.10) |
| -4 | -0.94 | 2.06 | -5.41 | -7.83 |
| | (3.11) | (3.42) | (5.56) | (5.05) |
| -3 | -3.51 | 1.82 | 2.90 | -6.34 |
| | (2.97) | (3.29) | (5.82) | (4.99) |
| -2 | -2.36 | -1.69 | -0.60 | -0.30 |
| | (3.10) | (3.06) | (6.42) | (4.94) |
| -1 | 1.25 | 1.82 | 3.60 | 2.54 |
| | (3.55) | (3.35) | (6.15) | (4.88) |
| 0 | 3.12 | 5.26 | 5.03 | -1.57 |
| | (3.10) | (3.62) | (6.90) | (4.82) |
| 1 | 1.67 | -4.78 | -5.02 | -5.71 |
| | (2.75) | (2.82) | (5.45) | (4.76) |
| 2 | 0.16 | 1.01 | -9.36 | -2.86 |
| | (2.74) | (2.78) | (5.22) | (4.70) |
| 3 | -3.36 | 3.22 | 3.51 | -2.53 |
| | (2.49) | (3.07) | (6.22) | (4.64) |
| 4 | | 1.42 | -5.22 | |
| | | (3.04) | (5.91) | |
| 5 | | 4.31 | -0.95 | |
| | | (3.24) | (5.55) | |
| 6 | | -1.62 | -0.94 | |
| in nonswitching | | (2.70) | (6.67) | |
| 7 | | 3.27 | 12.37 | |
| | | (2.87) | (6.96) | |
| 8 | | 1.00 | -0.26 | |
| | | (2.81) | (5.65) | |
| 9 | | -6.24** | 10.17 | |
| | | (2.40) | (7.07) | |
| Optimal bounds ($q_L$, $q_U$) | (-12, 3) | (-9, 9) | (-8, 9) | (-16, 3) |
| Observations | 4,483 | 4,498 | 4,474 | 4,481 |

Note: The dependent variable is quarterly hazard of myomectomy. The covariates are 5th order polynomial terms of quarterly ages. For brevity, we only present estimates of q between -12 and 9. Robust standard errors clustered at the birth cohort level are in parentheses. $^{**}, p < 0.01$; $^{*}, p < 0.05$.

Table A21: Disaggregated surgical expenditures due to inducement in balanced sample*

| Reimbursement | Total hysterectomy | | | Subtotal hysterectomy | | | Laparoscopic hysterectomy | | |
|---|---|---|---|---|---|---|---|---|---|
| of surgery type | Major | Minor | Community | Major | Minor | Community | Major | Minor | Community |
| by teaching status | Teaching | Teaching | | Teaching | Teaching | | Teaching | Teaching | |
| (Unit: NT$) | 44,332 | 42,412 | 41,055 | 40,334 | 38,414 | 37,057 | 63,260 | 61,510 | 60,305 |
| Government Insurance | 831 | 436 | 138 | 61 | 73 | 28 | 713 | 352 | 108 |
| Labor Insurance | 4,077 | 2,379 | 913 | 262 | 326 | 165 | 3,653 | 2,415 | 756 |
| Farmer Insurance | 502 | 553 | 200 | 24 | 35 | 22 | 646 | 802 | 189 |
| | 5,410 | 1,911 | 1,251 | 347 | 434 | 215 | 118 | 3,569 | 1,053 |

*Reimbursement rates of nine surgeries in 2005.

# Appendix B

In each panel, the black curve plots the counterfactual hazard distribution; the grey or colored curves are the actual hazard distributions. The counterfactual is constructed by fitting a fifth-order polynomial (except sixth-order for total oophorectomy) of quarterly ages on hazard data outside the lower threshold $q_L$ and the upper threshold $q_U$. The values of $q_L$ and $q_U$ are selected by a grid search over the ranges of $q_L \in [-18, -9]$ and $q_U \in [2, 12]$ to minimize the root mean squared error (RMSE) of the regression.

Figure B1: Actual and counterfactual hysterectomy hazards

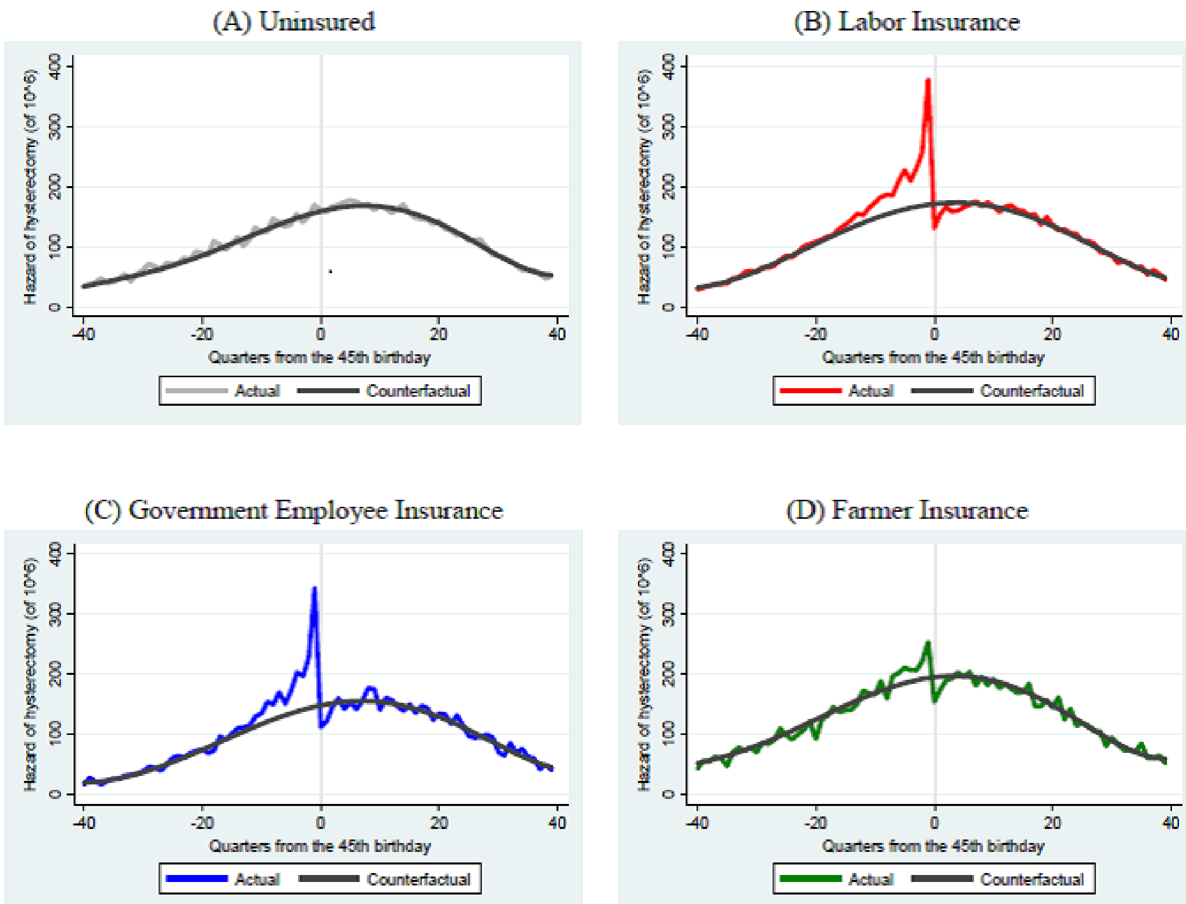

Figure B2: Actual and counterfactual oophorectomy hazards

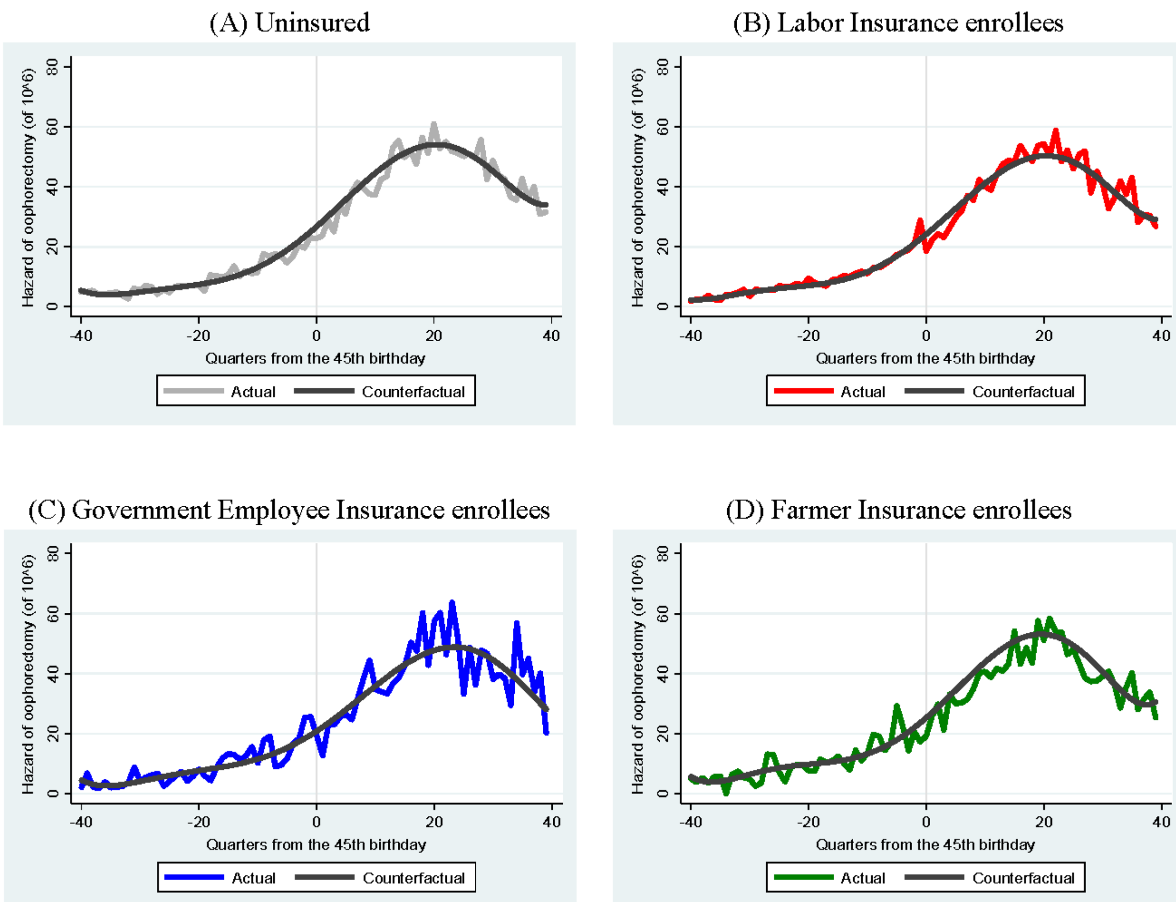

Figure B3: Actual and counterfactual partial oophorectomy hazards

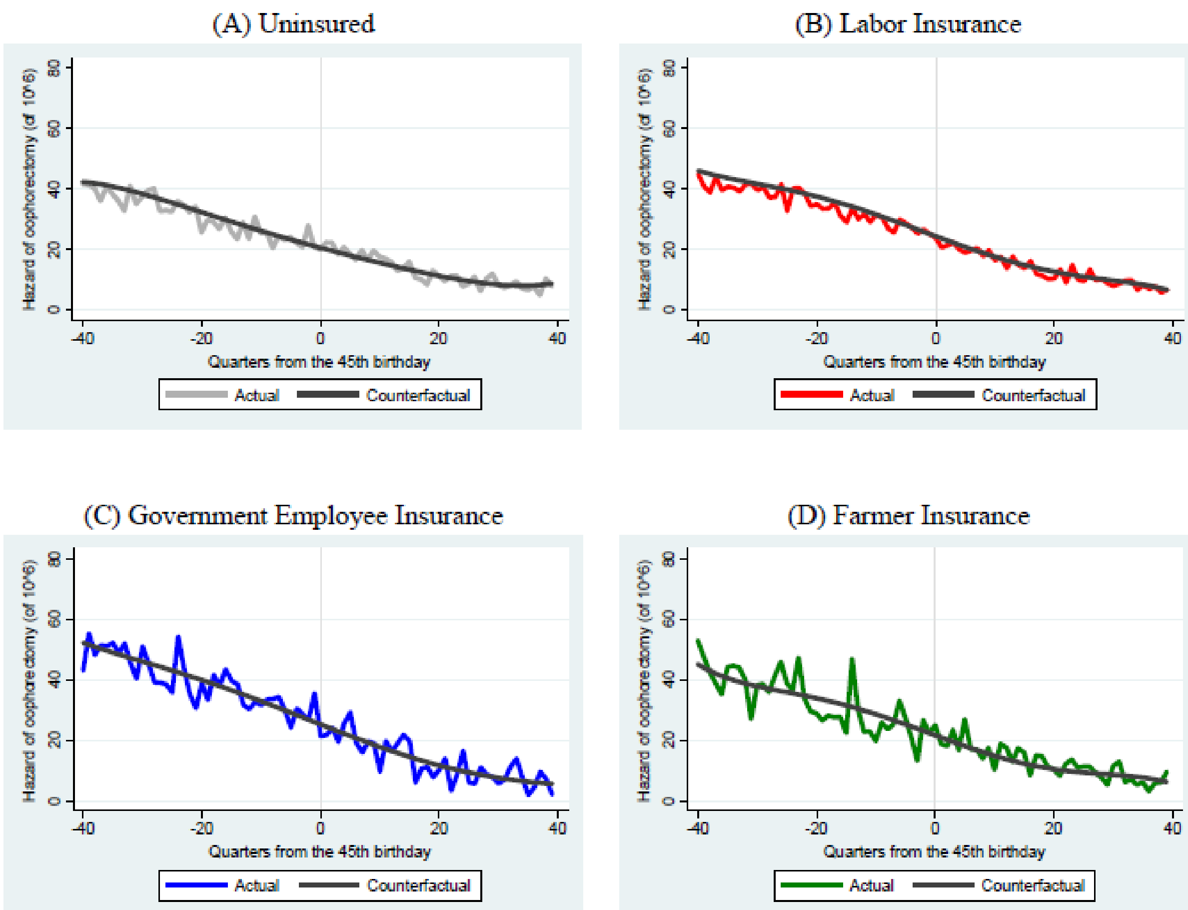

Figure B4: Actual and counterfactual myomectomy hazards