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ABSTRACT

More than one in four births are delivered by Cesarean section across the OECD where fee-for-service remuneration schemes generally compensate C-sections more generously than vaginal deliveries. In this paper, we exploit unique features of the Canadian health care system to investigate if physicians respond to financial incentives in obstetric care. Previous studies have investigated physicians' behavioral response to incentives using data from institutional contexts in which they can sort across remuneration schemes and patient types. The single payer and universal coverage nature of Medicare in Canada mitigates the threat that our estimates are contaminated by such a selection bias. Using administrative data from nearly five million hospital records, we find that doubling the compensation received for a C-section relative to a vaginal delivery increases by 5.6 percentage points the likelihood that a birth is delivered by C-section, all else equal. This result is mostly driven by obstetricians, rather than by general practitioners. We also find that physicians' response to financial incentives is greater among patients over 34, which may reflect physicians' greater informational advantage on the risks of different delivery methods for this category of mothers.

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1 Introduction

Unnecessary medical tests and procedures are a target of attempts to rein in the rising cost of health care. Caesarian section (C-section) births are a particular focus of this effort. The reasons are clear: First, C-section rates have been rising steadily over past decades in many developed countries. In figure 1 we graph the rates of C-section in a selection of countries of North America and Europe and in Australia. In each country the rates have increased between 32 and 79 percent since 1995. Second, despite the fact that the World Health Organization (WHO) has identified 15 percent as the highest C-section rate justifiable on medical grounds,[1] Gibbons et al. (2010) report in a WHO report that half of a sample of countries representing over 95 percent of global births had C–section rates in excess of this level. Note that in figure 1, the C-section rates in all six countries are above 15 percent throughout the entire period. Third, eliminating unnecessary C-section deliveries potentially delivers cost savings. For example, in both Canada and the US, C-sections are now the most common in-patient surgery (CIHI 2014, Pfuntner et al. 2013).[2] Fourth, C-section rates have been found to vary across countries, within countries and across hospitals, suggesting something more than the health of the mother and child is playing a role in defining the trends. Finally, C-sections are increasingly recognized as major surgery, posing significant, and perhaps avoidable, risks for both mother and child (SOGC 2004a).

There are a number of potential explanations for rising C-sections rates. The trend to delay childbirth—the risk of complication during labor increases with

[1] The guideline emitted by the WHO in 1985 stated: *"Countries with some of the lowest perinatal mortality rates in the world have caesarean rates of less than 10%. There is no justification for any region to have a rate higher than 10-15%."* World Health Organization (1985) This guideline has being re-examined in 2009 to conclude that no optimal C-section rate could be identified but that both very low and very high C-section rates could threaten mothers' and infants' health. The rates observed in most OECD countries were considered unreasonably high.

[2] C-sections totaled 100 686 surgeries in Canada in 2012-13. Knee replacements came second, with 57 829 occurrences. Over that same period, birth deliveries were responsible for nearly 370 000 inpatient stays, lasting on average 2.4 nights. The second most important factor for inpatient hospitalization during that period were respiratory diseases, with 76 705 occurrences (CIHI 2014).

maternal age—, and the higher incidence of multiple births due to fertility treatments are leading medical based accounts. Defensive medicine and risk avoidance—the risk of poor or catastrophic health outcomes for the mother and child and/or the risk of lawsuits in the rare event of failed vaginal delivery—on the part of health practitioners is thought to contribute, fanned by new technologies such as continuous electronic fetal monitoring. Finally, the convenience of C-sections is believed to appeal to both health professional and mothers. It precludes long periods of labor and offers more predictability to doctors' and mothers' schedules.

Economic research on the rising C-section rate has mostly focused on doctors' monetary incentives to perform the procedure, as predicted by the physician-induced demand model (Evans 1974). While previous studies (summarized below) suggest physicians' discretion plays some role, they typically focus on a select sample of births (e.g., patients covered by Medicaid), and/or study the practice of doctors who may have self-selected into reimbursement schemes. This means that the external validity of the existing evidence is uncertain, and it is difficult to construct an overall account of the contribution of prices to the rising C-section rate.

In this paper, we use data from Canada to investigate physicians' response to prices when choosing between two potentially substitutable procedures: vaginal delivery and C-section. Our focus on Canada offers important advantages. First, obstetric care in this country is remunerated according to fee-for-service agreements, so any role of relative prices should be straightforward to uncover.[3] Second, prices for these procedures vary substantially across the provinces of Canada and over time, providing an attractive framework for the identification. Finally, the health system in Canada is public (single payer) and universal, so we are able to consider the full

[3] In 2011-2012, more than 85 percent of Canadian physicians reported being mainly compensated fee-for-service agreements (National Physician Survey 2013).

population of hospital births within the country.

We find that doubling the compensation for a C-section relative to a vaginal delivery increases the likelihood that a physician opts for the former by just more than 5 percentage points, all else equal. The estimated response can account up to one ninth of the *excess* C-sections performed in the country over the period 1994-2010, using benchmarks set by the WHO. We also find that this behavioral response is driven by obstetricians/gynaecologists (OB/GYNs). In contrast, general practitioners (GPs), whose incomes rely less heavily on activities related to birth deliveries, do not exhibit price sensitivity.

2 Previous Research[4]

There have been a number of empirical studies investigating the relationship between a variety of incentives and C-sections. Gruber and Owings (1996) investigate how physicians adjust the proportion of births they deliver by C-sections (usually more generously remunerated than vaginal deliveries in fee-for-service contracts) in response to an income drop caused by an exogenous decline in the fertility rate. They find that a 10 percent decrease in the fertility rate leads to an increase of 1 percent in the C-section rate.

Other studies look directly at the impact of changes in the relative prices of C-sections and vaginal deliveries on birth delivery outcomes. Gruber et al. (1999) provide evidence that the C-section rate would rise by 7 percent in response that to a $100 increase in the compensation received for a C-section, all else equal.[5] Their

[4] In addition to the literature reviewed in Section 2.2, Appendix B surveys all medical practice guidelines and policy statements published by the Society and Obstetricians and Gynaecologists of Canada between 1994 and 2010. Some of these publications are likely to have directed and influenced physicians' practice while others may reflect trends in their choices.

[5] In a cross sectional study of birthing events in four hospitals in Cali, Columbia, Gomez and Carrasquilla (2012) also finds that privately insured patients, to whom physicians can charge more for health care, are more likely to get a primary C-section. The effect would be even stronger for repeat C-

results also suggest that 75 percent of the difference in the C-section rates for Medicaid patients and privately insured patients between 1988-1992 in the United States could be explained by the difference in the reimbursement parameters specific to each type of insurance coverage.[6] Alexander (2013) uses individual-level and hospital-level data from 1990 through 2008 and exploits the different financial incentives faced by fee-for-service and salaried American physicians to test for physician-induced demand (PID). She finds that an increase of $100 in the price differential between C-sections and vaginal deliveries would increase the rate of primary C-sections by 3.4 percent within the Medicaid population in counties without a salaried hospital.[7] She also finds that the higher C-section rate prompted by financial incentives had a small positive impact on infant survival rates.

Other research has directly exploited the asymmetry of information between obstetricians and their patients. Johnson and Rehavi (2014) find that, in the presence of financial incentives rewarding C-section, mothers who are physicians are 7 to 12 percent less likely to have a C-section than otherwise comparable mothers without medical knowledge. In line with the PID model, they find physicians' scope to respond to financial incentives is increasing in their informational advantage over their patients.

The identification strategy in most of these studies is based in one of two characteristics of the American health system: the difference in the fee structure for the care provided to Medicaid patients and to privately insured patients or the different remuneration agreements—fee-for-service versus fixed salary—offered across

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sections. They also find that 81 percent of all primary C-sections performed could find their justification on medical grounds.

[6] Grant (2008) argues that only one third of the effect measured by Gruber et al. (1999) remains when accounting for state-specific time trends and relaxing some sampling restrictions.

[7] Compared to Gruber et al. (1999), she examines a period during which patients had access to more information on birth delivery methods. This could contribute to explain the smaller estimates she obtains.

hospital types.[8] If physicians self-select on these same features of the system, any inference must be interpreted accordingly. For example, if physicians with a higher propensity to induce demand for C-section delivery choose to work in hospitals offering fee-for-service remuneration agreements, where they will have a greater control over their income compared to institutions offering salaried contracts, then estimates based on comparisons of salaried and fee-for-service physicians potentially overestimate the price response within the population of physicians. Likewise, in a multiple-payer system, physicians with a greater propensity for inducement could also orient their practice more heavily towards privately insured patients, for whom the C-section fee-premium is typically higher. Finally, if it the case that Medicaid patients are systematically different from their privately insured counterparts in ways that makes them more or less susceptible to their physician's influence, the results obtained may not apply to the population of patients as a whole.

In contrast the Canadian health care system does not allow physicians to choose between private and publicly insured patients and to self-select into remuneration agreements for obstetric care. Furthermore, our sample covers almost the entirety all births in the ten Canadian province over the period studied.

One of the only papers examining physician care around birth in an environment similar to Canada's, Jensen (2014) finds that changing physicians' remuneration from capitation to fee-for-service contracts, which increases incentives to provide more prenatal care, increases infant health for newborns, especially for younger mothers. Although the institutional context she exploits limits the risk of her

[8] One exception is the work of Kantaveric et al. (2008), who exploit a reform implemented in 1998 in Ontario, which imposed a ceiling on physicians' annual earnings. They investigate how physicians' choice of procedures changed as they reached the maximum amount that could be billed to the public insurance plan. They find evidence of a positive and significant price elasticity of the supply of medical care for OB/GYNs. However, their study speaks to the volume of total care, rather than to the substitution between medical acts.

results being driven by physician sorting, the study cannot directly measure the impact of incentives on the quantity or quality of care provided.

3 Other factors influencing C-section rates

Patients' preferences have also been offered as an explanation of the high volume of C-section deliveries. One story often played up in the media is that an increasing proportion of mothers request a C-section for aesthetic reasons, for fear of experiencing prolonged labor or for scheduling convenience. Testing this hypothesis is challenging; in Canada, for example, data on maternal requests for C-sections has not been collected consistently across provinces or over time. Despite this obstacle, a few studies argue that mothers' preferences could only play a marginal role in explaining the high rates of primary C-sections across the country. For example, using data from British Columbia (where mothers' preferences and requests for C-sections are more closely monitored), Hanley et al. (2010) provide evidence that only 2 percent of surgical deliveries are performed on mothers' requests without medical indication.[9]

Moreover, disentangling *ex-ante* preferences from the impact of inducement by a physician is not straightforward. In a medical note destined to Quebec physicians, Jimenez (2005) suggests that mothers' preferences and apprehensions regarding delivery methods would be strongly influenced by physicians' beliefs and advice, conveyed in the prepartum phase of obstetric care. Gamble et al. (2007) also highlight the role of the health system in general and of physician advice in particular on the formation of a patient's attitude and requests towards different modes of delivery.

In parallel, the medical and legal literatures have described how tort laws, initially adopted to deter negligence, have intensified the recourse to unnecessary

[9] The Canadian Health Services Research Foundation (2013) similarly finds that only 1 percent of C-sections in the United-States would be performed on the basis of explicit mothers' preferences and would not have been performed otherwise.

medical acts and contributed to a culture of defensive medicine. Using responses to the 2008 Health Tracking Physician Survey, Carrier et al. (2010) suggest that American OB/GYNs tend to overestimate the risk of a lawsuit in case of a problematic trial of labor—a risk that they would generally consider to be random—and try to avoid it by practicing defensive medicine. Interestingly, this would be observed for both fee-for-service and salaried physicians, suggesting that fear of malpractice cannot explain the different C-section rates observed between these two groups. Lawthers et al. (1992) and Keeler and Brodie (1993) also report that physicians providing obstetric care may try to minimize their potential exposure to lawsuits by performing "defensive C-sections".

Exploiting variation in the true exposure to malpractice suits across geographic zones, Baicker et al. (2007) find that high malpractice costs increase the utilization of medical imaging and of other diagnostic procedures, but not the frequency of major surgeries. On the other hand, Currie and MacLeod (2008) propose a theoretical framework in which increasing physician liability can reduce aggregate recourse to unnecessary C-sections by bringing their expected cost up. Their prediction hinges on the hypothesis that the probability of medical error—or bad outcome—is higher for unnecessary procedures. They find empirical support for their prediction in the context of the tort reforms implemented at the state level in the United-States between 1989 and 2001.

Another explanation for high C-section rates is technological change in health professionals' practice. Currie and MacLeod (2013) argue that the development of electronic fetal monitoring (EFM) technologies to assess mothers' and fetus' conditions during labor have had heterogeneous impacts on recourse to C-section across the distribution of physicians with different diagnostic skills. Using electronic birth certificates for New Jersey between 1996 and 2007, they find that physicians with a

limited ability to use new technology have increased their recourse to unnecessary C-sections among low-risk women following the introduction of EFM.[10]

Finally, there is very little evidence-based support in the literature for the general idea that physicians opt for C-section deliveries for scheduling convenience reasons (Lefevre 2013).

4 The Canadian health care system

4.1 System Parameters

Canadian health care is a universal, public, single payer system that operates at the provincial level and is funded by both provincial governments and by conditional transfers from the federal government. Most services are remunerated according to fee-for-service agreements, in which physicians are responsible for billing the public health insurance plan for each procedure they perform, at a fee administratively fixed by provincial authorities for a predetermined period of time, typically corresponding to a fiscal year. Fees do not evolve according to the relative movements of the demand and supply for different medical services. Physicians are moreover precluded by the Canada Health Act from billing their patients in addition to the fees they receive from the public insurer.[11]

In table 1, we present the incidence of fee-for-service compensation for obstetric care in seven provinces, for the fiscal years 2006-2007 to 2010-2011.[12] In the

[10] They also show that improving diagnostic skills among physicians could increase the proportion of high-risk women having a C-section and decrease the proportion of low-risk mothers giving birth by C-section. In aggregate, the impact on the latter group would outweigh the impact on the former, and a general appreciation in diagnostic skills would lead to a decrease in C-section rates.

[11] The single payer nature of provincial health care systems is directly inspired by the five principles on which rests the Canada Health Act: public administration, universality, accessibility, portability and comprehensiveness. Failure to satisfy those principles would result, for a provincial administration, in the loss of healthcare funding transfers from the federal government.

[12] The Canadian Institute for Health Information started compiling this information in 2006 only. As of 2010-2011, the data provided by Nova Scotia, Alberta and British Columbia did not allow to identify the proportion of payments made to OB/GYNS under fee-for-service agreements.

less populous provinces—Prince Edward Island, Newfoundland and Labrador, New-Brunswick, Saskatchewan—, the rates oscillate between 40 and 80 percent. In the more populous provinces—Ontario, Quebec and Manitoba[13]— fee-for-service payments almost always represent more than 85 percent of OB/GYNs' compensation over the entire period. These statistics could be expected to be even higher for birth delivery activities only; the statistics presented in table 1 cover all cares performed by OB/GYNs, including services other than birth delivery that are more likely compensated under alternative payment schemes. Therefore, Table 1 underestimates the role of fee-for service in intrapartum care, to which it applies almost exclusively (CIHI 2006).

Changes in the fees in each province are typically induced by external scientific assessments of changes in the relative level of effort or skills required to perform different medical acts, caused for example by technological evolution, modifications in medical protocols or in the training for certain areas of practices. Changes in fees may also reflect political considerations as the formal negotiation process involves the provincial government and the provincial medical association (or its designated tariff committee). However, the objective of these negotiations is mostly to determine the amount of the global envelope attributed to physician remuneration, rather than to determine the relative movements in specific fees.

It might be argued that the pressure exercised by a medical association on the provincial government could nonetheless drive relative prices in a certain direction. This is an unlikely scenario in the specific case of obstetrical fees; OB/GYNs constitute a particularly small voting within medical associations and typically have a very limited influence in the determination of specific fees in negotiations rounds

[13] These three provinces account for 63 percent of all births in our sample, as described in Section 5.

(Katz et al. 1997, Barer et al. 1996).[14] Moreover, each specialty represented in the association's tariff committee competes for its own financial interest against the other (Emery et al. 1999). The committees often ask that each specialty uses evidence or external assessment to legitimize it demands for specific fee increases, limiting the scope for endogenous price determination.

Another feature of the Canadian medical system relevant to this study is that physicians are effectively insulated from the impact of tort liability (Flood and Thomas 2012).[15] Therefore, the risks of financial—as opposed to the reputational—costs of malpractice are unlikely to play a significant role in Canadian C-section trends.

Overall, the parameters under which physicians operate in the Canadian health system provide us with the opportunity to identify responses to exogenous changes in relative fees with few risks of contamination of our estimates through selection of physicians and patients, or other incentives from the legal environment.

5 Data

5.1 Individual Data on Pregnancies and Obstetric Care

Our main source of data on birth deliveries is the Hospital Morbidity Database (HMDB), administered by the Canadian Institute for Health Information (CIHI), which covers the universe of administrative discharge records from acute inpatient

[14] On the other hand, the stronger negotiating power held by GPs would historically have been used to increase their global remuneration by increasing the fees corresponding to medical acts for which they have a monopoly, or premiums linked to special aspects of their practice.

[15] Almost all Canadian physicians subscribe to the Canadian Medical Protective Association (CMPA). The association negotiates with medical associations and provincial governments to establish regimes of medical liability protection for its members, along with patient compensation schemes. Although the premiums paid by physicians providing obstetric care are the highest among all specialties ($57 420 in Ontario, $20 304 in Québec and $38 102 in the rest of Canada in 2014), they are substantially —if not entirely— reimbursed by the government in most provinces. Flood and Thomas (2012) also observe that the CMPA has a very large war chest, a reputation of defending claims very aggressively—a "scorched earth" policy"— and does not experience rate premiums. Furthermore, under Canadian law unsuccessful plaintiffs may be required to pay up to two-thirds of a defendant's costs, which discourages malpractice claims.

facilities in all ten Canadian provinces. Our sample covers the administrative records for all hospital births between April 1994 and March 2011 for all provinces. The only exception is Quebec, for which our data covers the period from March 2006 to April 2011.[16]

The HMDB provides a wide range of demographic characteristics for each mother, such as her birth date, her province of residence, her health risk factors, some information on her current pregnancy and previous deliveries and details on the health conditions of the infant at birth (weight, injuries from the delivery, respiratory distress, etc.). It also contains detailed clinical information including the type of institution in which she gave birth, the date of her admission and discharge, the day of the week and time of the birth, as well as any information related to transfers to or from other institutions.[17]

Most importantly, the HMDB lists, for each mother, all interventions performed by physicians in acute care facilities prior to, during and after the delivery using the International Classification of Diseases codes (ICD-9, ICD-9-CM and ICD-10-CA)[18], the Canadian Classification of Health Interventions (CCI) and the Canadian Classification of Diagnostic, Therapeutic and Surgical Procedures (CCP). We observe any failed trial of labor or sign of maternal or fetal distress during the delivery. The medical records also identify the factors that are medically known to be associated with higher risks of caesarean deliveries: multiple pregnancy, placenta previa, malpresentation of the fetus, high maternal body mass index, maternal infection

[16]Unlike in other provinces where acute inpatient facilities are required to provide CIHI with all discharge records, the information on patients and care provided in Québec's facilities is compiled and transferred to CIHI by the Department of Health. Access to these files can be obtained only through a different data request. Our main results, however, are not sensitive to the exclusion of all observations from Québec.

[17]Although almost identical from files submitted by other Canadian provinces, the data files from Quebec exclude the delivery time for all births. Moreover, certain provinces do not provide full information on mothers' previous pregnancies (characteristics and outcomes).

[18] ICD-9 and ICD-9-CM codes were gradually replaced by ICD-10-CA codes starting from 2001. From 2004 onwards all provinces reported the diagnostics to CIHI using ICD-10-CA.

transmittable to the baby during a vaginal delivery, maternal diabetes, etc. (ACOG 2014, CIHI 2011, NICE 2012, Public Health Agency of Canada 2008).

Finally, the administrative records identify the specialty of the physician performing each act during the delivery process. When several providers are associated with a patient's episode of care, we use the type of the physician associated with the successful attempt of a delivery, but we nonetheless track any change in provider type for each patient.[19] Providers identified as family practitioners, general practitioners and community physicians are classified as GPs. Those identified as Obstetrician/Gynaecologists, Surgeons, Urogynaecologists, Specialists in Maternal-Fetal Medicine are classified as OB/GYNs (being more loosely defined as specialists).

We exclude from our final sample all deliveries that are assigned neither to a general practitioner (or family physician) nor to an obstetrician/gynaecologist,[20] since other health care providers may not get paid according to the same agreements and parameters. We also discard all records for mothers younger than 14 years old or older than 65 years old and for mothers without geographic (province) information. Our final sample consists of 4,846,847 mother records and the corresponding newborn records. The distribution of observations across provinces is reported in Table 2.

5.2 Price Data for Obstetric Care

We obtain information on the fees paid to physicians for obstetric care directly from CIHI's aggregate physician payment records extracted from the National Physician Database (NPDB). These records identify, for each province and on a yearly basis, the frequency at which physicians have claimed a payment for each medical act (as identified by its province-specific fee code) along with the total amount paid by the

[19] If an OB/GYN and a GP are both associated with a single delivery, the delivery is classified as being performed by an OB/GYN. In most cases where this situation would arise, the GP would be paid a fixed amount for assisting the delivery, this amount being fixed across delivery types. As a robustness check, we also consider the type of the first provider associated with an attempt of delivery. The direction and significance level of the results are insensitive to that variation in the definition of physician type.

[20] These deliveries, when not assisted by a physician, account for 6.95 percent of all records.

single-payer for that same procedure, which allows us to obtain a unit price for each procedure. Moreover, payments made for deliveries are listed separately from additional payments made for ancillary procedures executed alongside deliveries, allowing us to define baseline prices for vaginal deliveries and C-sections that are comparable across provinces and through time.[21] As an additional check, we compared the prices obtained from the NPDB with those listed in the original annual fee schedules published by provincial health authorities and medical associations on an annual basis. We link our price data to our patient data using the fee codes listed in the NPDB and the corresponding medical services recorded in the individual discharge records.[22]

5.3 Descriptive Statistics

The average C-section rate in the full sample is 23.7 percent. Excluding all Caesareans for cases of fetus malpresentation (including breech presentation) and multiple pregnancies, that rate falls to 18.6 percent. During the same time period, the average fee billed by a physician for a C-section delivery across all provinces was approximately 18 percent higher than the average fee billed for a vaginal delivery. The difference in prices between the two procedures, however, exhibits considerable heterogeneity across provinces and through time. For example, in Manitoba in the mid 1990s, the compensation for a C-section was nearly 30 percent higher than the payment received for a vaginal delivery.

Table 3 compares average maternal and pregnancy characteristics across

[21] The fees associated with C-sections and vaginal deliveries are therefore free of the endogeneity concerns associated with bundled payments that would reflect both the administrative prices included in the fee schedule and the choice of physicians over the set of ancillary services to bill.

[22] The payment records from the NPDB inventory provide an alternative source of information on birth procedures performed by physicians remunerated under fee-for-service agreements. We have constructed a data set at the aggregate level (each observation corresponding to the combination of a province and a year) on the incidence of C-section and vaginal births using this source. Unlike the HMDB, NPDB payment records inventory solely birth deliveries performed by physicians remunerated under fee-for-service agreements. Therefore, examining C-section rates in the NPDB provides a robustness check for our main results; the presence of birth deliveries not remunerated according to fee-for-service agreements in our individual-level data could bias our estimated physician response to financial incentives towards zero. Our results are however consistent across data sources.

delivery outcomes and provides the average of each variable in the full sample.[23] Mothers are on average 29 years of age at delivery, and mothers delivering by C-section are older than mothers delivering vaginally (aged 30.2 versus 28.6 for women having a vaginal delivery). Underlying this difference is that women older than 40 are overrepresented in the C-section group (4.2 percent versus 2.1 percent). This higher proportion of older mothers delivering by C-section is likely due, in part, to the fact that pregnancy at older ages is associated with specific risks and complications during labor (Joseph et al. 2005).

The data also indicate that cases of multiple pregnancy, breech presentation or other malpresentation and mothers with a previous C-section also have higher C-section rates. The proportion of deliveries performed on weekends is also significantly lower for C-sections than for vaginal deliveries, which might simply be due to hospitals' constraints on the availability of operating rooms for planned surgical procedures, or might attest to the scheduling convenience of C-sections from a physician's perspective. Finally, C-section deliveries are associated with longer inpatient stays and with a higher probability of exceptional postpartum complications leading to long-term hospitalization.

Of all births recorded in our sample, more than 73 percent were delivered by OB/GYNs, 4 percent of which were initially supervised by GPs. Among deliveries transferred from GPs to OB/GYNs, 32 percent ended in a C-section, 19 percent in an operative delivery and 7 percent were cases of fetus malpresentation. Of all mothers seen by an OB/GYN from the beginning, 31 percent delivered their child by C-

[23] Data on mother's schooling and marital status are not available at the individual-level. Each observation is therefore matched to the corresponding province-year level proportion of married women and of women with the mentioned schooling level, as published by Statistics Canada. For those variables, the proportions reported in Table 3 are provincial rates, weighted by the number of individual events corresponding to each delivery method for each combination of province and year. The resulting measures are relatively similar across the three groups: the average province-year rate proportion of women with some postsecondary education is around 50 percent, the proportion with less than 8 years of schooling is 2 percent and the average province-year marriage rate is 66 percent.

section; for mothers seen by a GP from the beginning, that proportion falls to 4 percent. Overall, across the provinces, GPs' share of delivery decreased from 31 percent in 1994 to 26 percent in 2010, with a low of 21 percent in 2005; meanwhile, their share of all C-sections performed decreased from 8 percent to 3 percent.

In figure 2 we present the evolution of the C-section rates and the ratio of prices for C-section versus vaginal births, by province for our sample period. C-section rates for births attributable to multiple pregnancies or malpresented fetus are stable in all provinces throughout the period (at levels between 5 percent and 8 percent of all deliveries), and uncorrelated with movements in the relative prices. There also appears to be a positive—although imperfect—correlation between the total C-section rate and the movements in prices, especially in Alberta, British Columbia, Ontario and Prince Edward Island.

Figure 2 also suggests that in all provinces, the total C-section rate increased at a faster pace starting around the year 2000. A few factors may have led to this development. One potential influence is the publication of the "Term Breech Trial" (Hannah et al. 2000). Based on a cross-country randomized trial, this study concluded that C-section was safer for mothers and fetuses than vaginal deliveries in cases of breech presentation. Although figure 2 provides no visual evidence that this study led to an increase in the proportion of breech presentations resulting in a C-section, the report may have contributed to a general increase in the C-section rate by influencing the general perception of the relative safety of this mode of delivery. Second, following the publication of the Trial, official announcements from relevant professional associations highlighted the importance of respecting patients' choices and of supporting elective caesarean delivery in a normal pregnancy (SOGC 2004b, Singer 2004). Finally, rapid improvements in electronic fetal monitoring technologies over the past decades made it easier to detect or foresee fetal distress during labor, and

to respond by opting for a surgical delivery. Technological improvements may therefore have contributed to the rise in C-section rates in many provinces in the early 2000s (Chaillet et al. 2007).[24]

Figure 3 maps the trends in some leading traditional medical indicators for C-section births in the sample. While the increase in the rate of pregnant women with a previous history of C-sections over time is a mechanical consequence of the rise in the caesarean section rate, the rate of repeat C-section is around 83 percent at the national level, partly because previous C-sections increase the risks of uterine rupture and placenta previa in subsequent pregnancies (Shearer 1993, ACOG 2013, NICE 2014). Moreover, maternal age increased steadily in all provinces between 1994 and 2010. In 2008, nearly one third of all first time mothers were older than 34 years of age (Leon et al. 2011).

6 Econometric model and empirical strategy

Our main estimating equation is:

$$CSection_{ipt} = \alpha + \beta RF_{pt} + Z'_{pt}\gamma + X'_{ipt}\phi + \delta_t + \lambda_p + \varepsilon_{ipt} \qquad (1)$$

where *CSection* is a binary variable indicating if a birth i in province p and year t was delivered by C-section, *RF* is the ratio of C-section to vaginal delivery fees, Z is a vector of time varying characteristics at the provincial level, X is a vector of time varying characteristics at the birth level and δ and λ are time and province fixed effects respectively. Standard errors are clustered at the province-year level. To allow for the potential serial correlation of the error terms within each province, we have also estimated the standard errors clustered at the province level only, using critical values from a t-distribution with G-K degrees of freedom, as suggested in Donald and

[24] The Society of Obstetricians and Gynaecologists of Canada suggests that recourse to intensive electronic fetal monitoring may result in more instances of false positive diagnoses of fetal distress (mostly hypoxemia) leading to higher rates of caesarean sections (Chaillet et al. 2007).

Lang (2007), and using block bootstrap methods. The standard errors obtained using these alternative methods do not alter the significance of our results.[25]

Equation (1) includes an extensive set of maternal health conditions and characteristics related to the pregnancy, included in the set of variables *X*, specific to each observation. These include—but are not restricted to—maternal age, indicator variables for any anomaly in the presentation of the fetus, multiple pregnancy, post and pre-term delivery, previous C-section, and other relevant health conditions of the mother. As discussed in Section 5, some of these characteristics, in addition to having an impact of the delivery outcome, have followed specific trends throughout the period considered.

The empirical model also includes a vector of observable province time-varying characteristics, *Z*, including the general level of education of women in the population as well as their unemployment and marriage rates, changes in the fertility rate, the gender ratio among physicians, a measure of GDP per capita and an indicator variable for the regulated status of midwives as health professionals in the province. These characteristics are added to capture the impact of features in the environment of physicians that might affect their practice conditions and their capacity to induce a demand for C-sections among their patients.[26]

[25] We use the LPM framework to preserve comparability with most previous studies using American data. The marginal effects only change slightly when the model is estimated as a probit.

[26] In certain specifications of the model, we also added variables related to immigration flows and to the amount of resources available to physicians within the health system (supply of registered nurses, percentage of hospital budgets spent on administrative expenses, etc.). The results were insensitive to the addition of these variables. All province-level characteristics come from Statistics Canada, CIHI and the Canadian Association of Midwives.

7 Results

7.1 Baseline Results

Estimates of equation (1) for our full sample of births are presented in table 4. In the first columns of table 4, we use the ratio of the prices for C-section and vaginal deliveries as a measure of the price incentive for caesareans. In column (1) are the results controlling for a limited set of birth characteristics and no province level characteristic. The estimated price effect is positive, 0.059, and statistically significant. The propensity of a physician to perform a delivery by C-section, holding other factors constant, is increasing in its relative price. In columns (2) and (3) we add additional characteristics of the birth and the province levels controls. The additional controls reduce the magnitude of the estimate of β, although only marginally; the estimate in column (3) implies that raising the price of a C-section by 100 percent relative to the baseline price of a vaginal delivery would increase the probability that a physician opts for a surgical delivery by 5.6 percentage points, all other factors kept constant. Given the average C-section rate of 23.7 percent and the corresponding average price ratio of 1.18 between 1994 and 2010, physicians' response to price incentives would explain 11 percent of the gap between the observed C-section rate in Canada and the benchmark of 15 percent set by the WHO.

In the next three columns we use the price difference, in 2002 dollars, between the two methods of delivery as our price variable. Again we estimate a positive and statistically significant relationship between the financial incentive and the volume of C-sections, which does not vary much as we increase the number of controls in the estimation. Also, the estimates of the parameters on the additional control variables are very similar to their counterparts in columns (1) to (3). In this case the estimate of the price incentive is columns (5) or (6) indicate that, keeping all other factors constant, increasing the difference between the payment received for C-section and the

payment received for a vaginal delivery by $100 (2002 dollars) would increase the probability that a physician opts for a caesarean delivery by 1.4 percentage points, an increase of 5 percent in the average c-section rate between 1994 and 2010.[27] These estimates include all the birth deliveries between 1994 and 2010 including those by physicians under alternative payment plans than fee for service and as such are likely a lower bound on the full price effect. [28]

Our results are in line with the conclusions of Clemens and Gottlieb (2014), who suggest that, when they have limited capacity to adjust the volume of care, physicians respond to price incentives by adjusting the intensity of the care they provide. Our estimated price effects are smaller than some presented in previous studies looking at physician responses to financial incentives. As previously mentioned, this could be due to the combination of two factors. First, the Canadian context does not allow physicians who wish to perform more C-sections to sort into institutions offering a fee-for-service remuneration, nor does it allow them to target their practice towards privately insured patients to maximize their net gain from each C-section performed. This limited scope for physician sorting should limit any impact of this sort of selection bias. Second, our estimates are obtained using the full population of births rather than a subset of Medicaid patients. It might be the case that this larger population is more likely to contain individuals whose greater access to information limits the influence exercised by their physicians on their choice of delivery method.

The estimates on most of the birth characteristics have the expected impact on

[27] Evaluated at the sample mean of the price difference for the two procedures ($70), these estimates also imply that one ninth of the excess C-section rate in Canada between 1994 and 2010 could be explained by the presence of financial incentives to opt for surgical deliveries.

[28] In 2013, only approximately 6.2% of OB/GYNs were salaried, while 17.1% of GPs were salaried or received most of their income under a capitation agreement or contracts (National Physician Survey, 2013).

the probability of C-section. Often a substitute to surgical delivery when complications arise in the second stage of labor, the estimated coefficient for operative delivery (the use of forceps or vacuum assisted delivery) is negative and statistically significant. Characteristics of the pregnancy such as malpresentation of the fetus (including breech presentation) and previous C-section are, on the other hand, strong, positive and significant associates of C-sections, each increasing by half the chances of surgical delivery. Multiple pregnancy is also a significant predictor of the delivery outcome, although the magnitude of its coefficient may be mechanically attenuated by the fact that in most cases, at least one of the fetuses is not in a vertex position, a characteristic captured by the malpresentation dummy variable.

The coefficient estimates associated with the full set of age dummies, not reported in the table for brevity, indicate an increasing probability of C-section with age. This is firstly the mechanical implication of maternal age on potential complications in prepartum and intrapartum care, especially in the form of dystocia (Leon et al. 2011). Since a small subset of intrapartum complications cannot be precisely accounted for as individual control variables, the age dummies could be picking up some of this impact. Secondly, although C-sections performed upon patients' requests without medical indication account for a minor proportion of all deliveries (Canadian Health Services Research Foundation 2013), the increasing coefficients associated with the age dummies could reflect the fact that physicians would have more facility to induce a demand for C-sections among older patients. This would be the case if preferences for non-surgical delivery methods were decreasing with age, or if the fear of labor complications increased with age. Knowing that they are categorized as *high-risk* pregnancies, mothers aged 35 or more might overestimate the risks associated with a vaginal delivery and respond more positively when offered a C-section. In the same spirit, Jensen (2014) provides empirical

evidence that maternal age is positively correlated with demands for more intense obstetric care from patients. Looking specifically at the experience of Canadian mothers, instances of planned C-sections increase with maternal age and education level, without being completely matched by cases of medical indication.

To investigate this potential channel, we use two approaches. As a first step, we estimate equation (1) on a subset of mothers aged 35 or older, still controlling for a full set of age fixed effects. We obtain a coefficient associated with the price ratio of 0.072, which is 28 percent larger than in the full sample and significant at the 1 percent level. We also estimate, using the full sample, a variant of equation (1) that adds an interaction term between the price variable and of a dummy variable indicating if the patient is at least 35 years old. If maternal age directly changes the likelihood of giving birth by C-section but also has the indirect effect of giving greater scope for inducement to the physician, the coefficient on age dummies should be increasing in age and the coefficient associated with this interaction term should also be positive. Alternatively, if maternal age does not matter for inducement, the interaction term coefficient should be equal to zero. Finally, if financial incentives, however, have no impact on the probability that a woman of more than 34 years has a C-section, the coefficient on the interaction term should be negative and of a magnitude comparable to that associated with the price variable alone. Adding this interaction term does not change the magnitude or the significance level of the estimated price effect (0.062) and we obtain a positive and significant coefficient on the interaction term (0.019). This empirical finding supports the intuition that a physician can use more discretion when mothers are older.

In table 5 we present some robustness checks for our results. First, we estimate the model using a sample excluding all cases of fetus malpresentation, previous c-sections and multiple births, cases for which medical factors could play an important

role.[29] The estimates of the price incentive (price ratio) are smaller, although very modestly so suggesting that there is likely less discretionary influence among this sub-sample. In the next two rows we investigate whether the greater sensitivity of C-section delivery to the price incentive for older mothers is driving the population results. However, restricting the sample to mothers less than 40 years old, or 35 years old we obtain estimates very similar to those in the full sample. The fourth row lists the coefficients and marginal effects obtained using a probit model, which are very similar to their counterparts obtained with a linear in probability model.

In the final row of table 5 we present the results adding province specific trends to the baseline specification.[30] We find that the coefficient associated with the price variable decreases in magnitude and reaches values that are not significantly different form zero. Therefore, the price effect on the C-section rate that we have estimated is not distinguishable from the impact of a province specific trend.

The meaning of this result is not entirely clear. Traditionally the addition of jurisdiction specific trends in this context is viewed as an additional control for dynamic unobserved factors that are correlated with both the dependent variable and the main explanatory variable of interest. Research on minimum wages (e.g., Baker et al. 1999, Neumark et al. 2013) and divorce rates (e.g., Frieberg 1998, Wolfers 2006) are other examples where inference is sensitive to the addition of these trends. However, the discussion in these literatures also suggests that such trends can partial out the main effect of interest in addition to any dynamic unobserved effects. This is particularly true when any response to a change in the variable of interest can also be expected to be dynamic. As Solon and Lee (2011) observe, when policy responses are dynamic, identification in these models suffers.

[29] Because of the various guidelines emitted by the SOGC promoting attempts of vaginal delivery for all those cases, however, we keep them in the sample to derive our main results.
[30] The results remain similar when using nonlinear trends (quadratic or trends of higher order).

In the current context it is reasonable to expect that there would not be a sharp jump in C-section rates to a change in relative prices. The price incentive must be weighed against other considerations such as the well being of patients and any other moral costs. Furthermore at the time of a price change, a doctor's obstetrics patient load for at least the short term is in place, and opportunities to change the planned course of care may be limited.

Another consideration is the type of dynamic unobserved factors the trends are intended to capture. Two possibilities are patients' preferences and physicians' preferences. Previous studies have identified age, previous C-sections, education and GDP per capita as the main drivers of patient preferences for c-sections (Bewley and Cockburn 2002, Moffat et al. 2007, Mazzoni et al. 2011, Gamble and Creedy 2001, Torloni et al. 2013). Given that these variables are all included in the empirical analysis, it is likely that changes in patients' preferences at the provincial level are picked up even in the absence of province-specific time trends. As for physician preferences, they would need to evolve differently across provinces, independently of any price incentive, to justify the use of province-specific time trends. This situation is unlikely to arise. On the one hand, most medical guidelines likely to influence doctors' preferences are determined at the federal level. On the other hand, the results obtained without province-specific time trends are robust to the inclusion of various factors influencing physicians' working environment within a province and measured annually.[31]

[31] These factors include the supply of registered nurses, the number of registered midwives, the government's expenditure in health care facilities, changes in population growth and in economic growth, the average age of the medical equipment. The results are also robust to the inclusion of the proportion of deliveries by specialists, annually for each province. However, that last variable is likely to be endogenously determined, therefore the results presented in table 6 and table 7 exclude it.

8 Results by Physician Specialty

Birth deliveries, including C-sections deliveries, can be performed by both OB/GYNs and GPs in Canada. GPs typically have a varied practice of which obstetrics is only one component. In contrast OB/GYNs' practice is more focused on obstetric care and deliveries. Therefore, we might expect that any discretionary contribution of the price incentive to the choice of delivery methods would be larger for OB/GYNs because birth procedures represent a larger proportion of their incomes.[32]

In table 6, we present estimates for the subsamples of births delivered respectively by GPs and OB/GYNs, using the price ratio as the measure of financial incentives. In column (1), we reproduce column (3) of table 4, our baseline results estimated from the full sample of all births delivered by either type of physicians.

In columns (2) and (3) are estimates for the GP and OB/GYN samples, separately. As shown in column (2), there is no statistically significant evidence that GPs respond to the price incentive by increasing their recourse to C-section when it becomes more lucrative to do so. On the other hand, the OB/GYN response is moderately larger than in the baseline results, as shown in column (3). As hypothesized it is OB/GYNs—who derive a greater percentage of their income for birth procedures—who exhibit the greater sensitivity to the changes in the price of a C-section compared to that of a vaginal delivery. Presented in column (5), the estimates from the pooled regression allowing the full set of interactions between the OB/GYN dummy and all other variables in the baseline specification also suggest that this difference in price response between GPs and OB/GYNs is statistically significant at all conventional levels. It also suggests that the positive and statistically significant price sensitivity presented in table (4) would be primarily driven by the behavior of

[32] In 2006, the average annual payment for obstetric care was $82 000 for OB/GYNs and $12 000 for GPs (CIHI 2006).

OB/GYNs in the sample, and that responses are heterogenous across physician type.

There are also some interesting differences in the estimates for some of the other control variables between the two samples. First the association between malpresentation and C-section is more than twice as large in the OB/GYN sample; however, this could simply reflect the fact that patients are not randomly assigned to physicians, and it is likely that the most complicated cases of malpresentation (which are also the cases that are most likely to necessitate a c-section) be allocated to OB/GYNs during the pregnancy and prior to the delivery.[33] The same reasoning could apply to cases of pre-term and post-term births. On the other hand, the coefficient associated with a multiple pregnancy is smaller for OB/GYNs (although it is positive and statistically significant for both types of physicians). The varying degrees of gravity coming with the diagnostic of twinning, and on which patients could differentially sort across physicians, is more likely to come from other related pregnancy characteristics (malpresentation, preterm, etc.). Once this sorting has occurred, and controlling for all other factors, it could be the case that OB/GYNs have a greater expertise in delivering twins vaginally, thus leading to the impact of multiple pregnancy on the probability of c-section to be smaller among that group.

9 Conclusion

In this paper, we use the unique features of the Canadian health care system — universality, single-payer nature and prevailing fee-for-service physician remuneration model— to estimate the impact of financial incentives on physician behavior. More specifically, we investigate how differences in physician compensation across birth delivery methods influence cesarean section rates. Our contribution is threefold. First,

[33] To avoid the possibility that these results be driven by the transfer of certain complex cases from GPs to OB/GYNs during the intrapartum care phase of the delivery, we also looked at a sample excluding all such cases of transfer. The results, presented in table 7, do not change much after this sample restriction.

our empirical approach rests on an institutional context that allows us to estimate responses that are free of the self-selection bias that may arise when physicians can sort across remuneration agreements. Second, we provide some evidence that behavioral responses to price incentives are heterogeneous across physician types. Finally, we assemble a new and unique dataset by merging the hospital records associated with nearly all births in Canada between 1994 and 2010 to the prices listed in physician remuneration schedules over that entire period, for each province.

Using information from nearly 5 million birthing events over 17 years, we find that doubling the payment received by a physician for a C-section relative to a vaginal delivery could raise by more than 5 percent the of surgical delivery. This behavioral response could explain one ninth of the difference observed over that period between the average C-section rate in Canada and the benchmark of 15 percent set by the WHO. This response is mainly driven by OB/GYNs, for whom the choice of birth delivery method represents an important margin along which to ad- just in order to increase total remuneration. As C-sections represent, by far, the main cause of surgery in Canada, these findings constitute an insightful basis for policy initiatives that would seek to improve the efficiency in the allocation of resources within the health care system. Moreover, our results indicate that other factors such as improvement in fetal monitoring technology, delayed motherhood, and the practice of defensive medicine to avoid suits for medical malpractice are likely to have also contributed to the increase in C-section rates over the last decades, since price incentives can only partially explain this rise.

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Figure 1: Evolution of C-section rates, selected OECD countries, 1995-2011

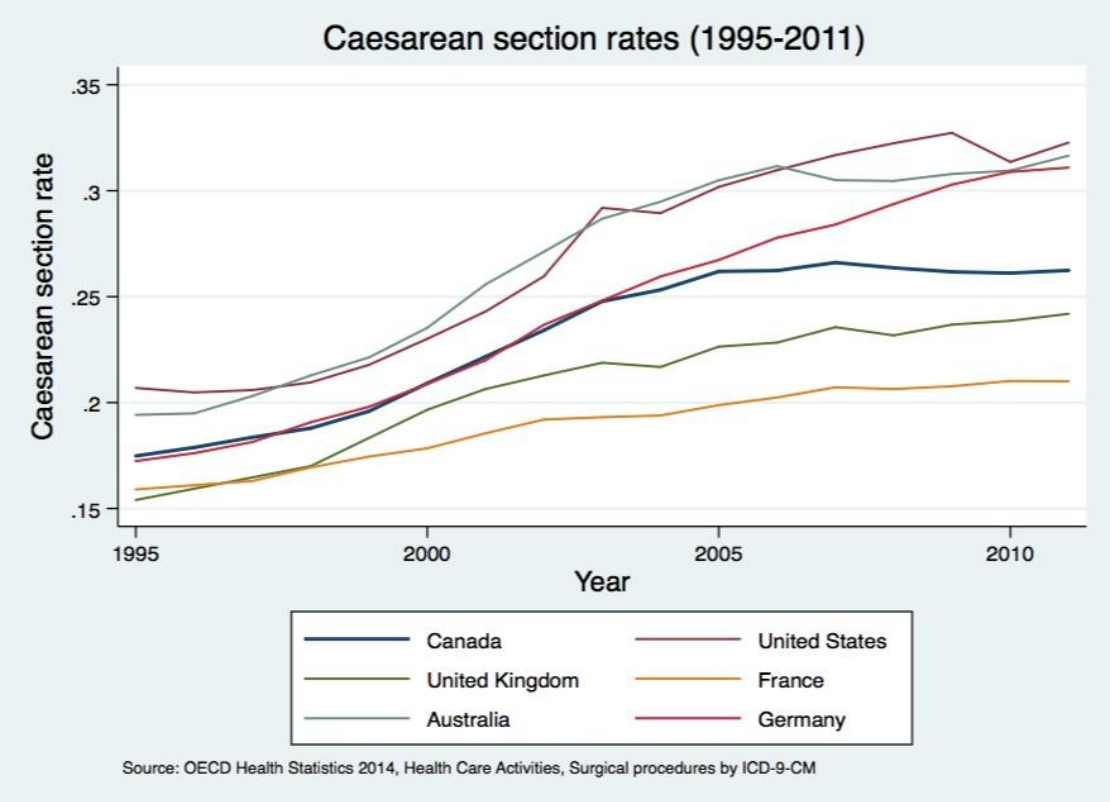

Figure 2: Evolution of caesarean section rates and relatives prices, by Canadian province, 1994-2010

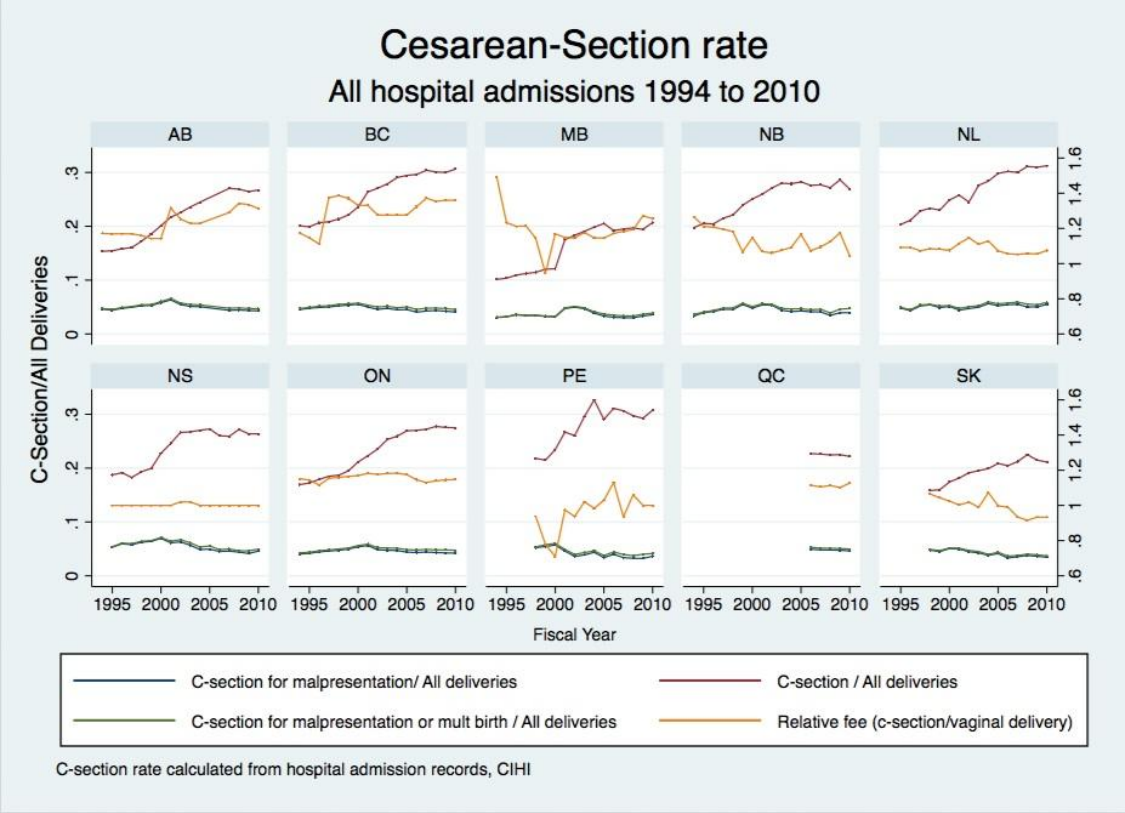

Figure 3: Evolution of selected mothers and pregnancy characteristics, by Canadian province, 1994-2010

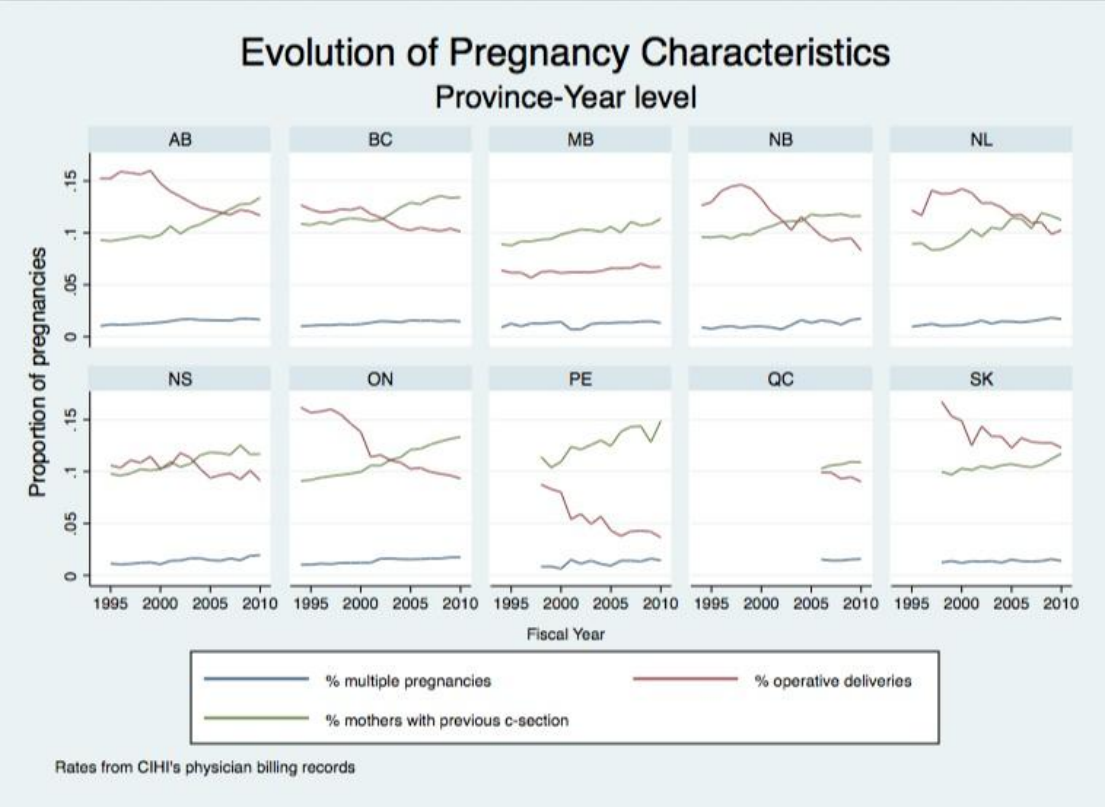

Figure 4: Share of birth deliveries by general practitioners, by Canadian province, 1995-2010

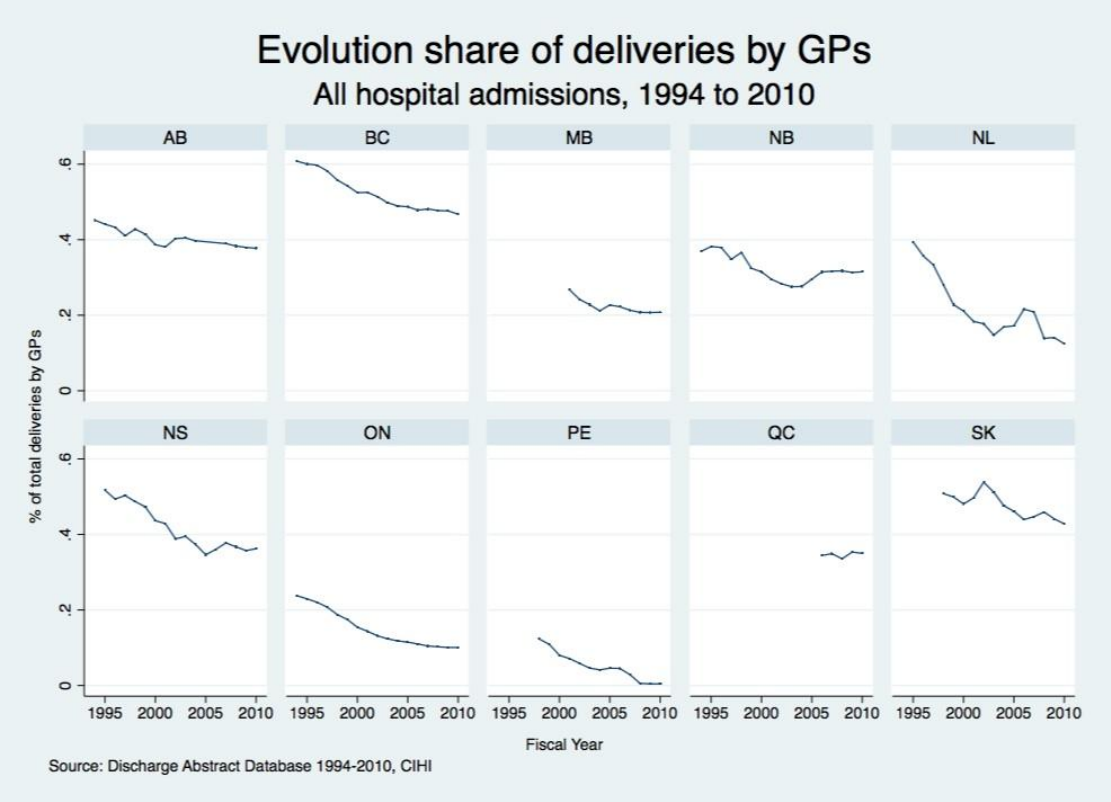

Table 1: Fee-for-service payments as a share of total physician total payments made to OB/GYNs

	2006-2007	2007-2008	2008-2009	2009-2010	2010-2011
Newfoundland	63.0	62.6	60.0	61.9	56.6
Prince-Edward	52.9	40.6	47.9	47.7	46.6
Nova-Scotia	n/a	n/a	n/a	n/a	n/a
New-Brunswick	79.8	81.0	77.4	79.0	69.3
Quebec	88.8	88.3	87.3	88.3	89.3
Ontario	90.5	90.7	84.8	87.7	87.9
Manitoba	89.2	88.2	88.2	87.4	87.0
Saskatchewan	75.3	75.3	76.9	76.4	72.7
Alberta	n/a	n/a	n/a	n/a	n/a
British-Columbia	n/a	n/a	n/a	n/a	n/a

Source: National Physician Database, Canadian Institute for Health Information.
Notes: These payments represent all activities related to obstetric and gynaecologic care; they are not limited to birth deliveries. n/a indicates provinces and years for which the information is not available.

Table 2: Mother records included in the HMDB for 1994-2010, by province

	Observations	Multiple Births	C-sections
Newfoundland	76 800	1 059	20 841
Prince-Edward Island	17 955	219	5 099
Nova-Scotia	145 369	2 094	35 347
New-Brunswick	128 190	1 499	32 865
Quebec	412 998	6 369	95 474
Ontario	2 327 572	33 397	552 643
Manitoba	250 763	2 561	46 484
Saskatchewan	164 570	2 308	33 198
Alberta	613 066	9 292	13 684
British-Columbia	709 564	9 761	188 898

Notes: Observations from Quebec for the fiscal years 1994-1995 to 2005-2006 and from Alberta for the fiscal years 2005-2006 and 2006-2007 are not available. Sample restricted to mothers between 14 and 65 years of age, whose birth was assisted by a physician (general practitioner or specialist).

Table 3: Means of main variables, by delivery method

	Vaginal Delivery	C-section	Full Sample
Age	28.59	30.23	28.98
Age > 40 years	0.021	0.042	0.026
Age > 35 years	0.147	0.228	0.166
Post secondary education	0.504	0.513	0.506
School < 8 years	0.002	0.019	0.019
Married	0.664	0.667	0.665
Length of stay (days)	2.264	4.115	2.702
Stay > 1 month	0.001	0.004	0.001
Multiple births	0.008	0.034	0.014
Fetus malpresentation	0.030	0.203	0.071
Pre-term delivery	0.089	0.090	0.089
Post-term delivery	0.104	0.099	0.103
Previous C-section	0.036	0.365	0.114
Operative delivery	0.153	0.008	0.119
Induced labor	0.209	0.158	0.197
Week-end delivery	0.247	0.163	0.227
Observations	3 698 314	1 148 533	4 846 847

Notes: All differences in means are significant at the 5% level. Marital status and highest level of schooling achieved are obtained at the province-year level from Statistics Canada.

Table 4: Base Estimates of the Impact of Prices on C-section rates

	Price Ratio (CS/VD)			Price Gap (CS-VD)/100 ($2002)		
	(1)	(2)	(3)	(4)	(5)	(6)
Price incentive	0.059***	0.060***	0.056***	0.011***	0.014***	0.014***
	(0.011)	(0.009)	(0.010)	(0.003)	(0.002)	(0.003)
Multiple pregnancy	0.121***	0.144***	0.144***	0.121***	0.144***	0.144***
	(0.005)	(0.005)	(0.004)	(0.005)	(0.005)	(0.004)
Fetus malpresentation	0.468***	0.469***	0.469***	0.468***	0.469***	0.469***
	(0.009)	(0.007)	(0.007)	(0.009)	(0.007)	(0.007)
Pre-term		0.010***	0.010***		0.010***	0.010***
		(0.002)	(0.002)		(0.002)	(0.002)
Post-term		0.055***	0.055***		0.055***	0.055***
		(0.001)	(0.001)		(0.001)	(0.001)
Operative delivery		-0.217***	-0.217***		-0.217***	-0.217***
		(0.002)	(0.002)		(0.002)	(0.002)
Induced labor		-0.003	-0.003		-0.003	-0.003*
		(0.002)	(0.002)		(0.002)	(0.002)
Previous C-section		0.561***	0.561***		0.561***	0.561***
		(0.007)	(0.007)		(0.007)	(0.007)
Province controls			✓			✓
Province FE	✓	✓	✓	✓	✓	✓
Year FE	✓	✓	✓	✓	✓	✓
Age FE	✓	✓	✓	✓	✓	✓
Observations	4 846 847	4 846 847	4 846 847	4 846 847	4 846 847	4 846 847
R^2	0.108	0.318	0.351	0.108	0.317	0.351

Notes: Province controls include: women's unemployment rate, proportion of women with a university degree, proportion of women without a high school degree, proportion of women physicians, supply of nurses, population growth, dummy variable for legislation over midwifery. Columns (2), (3), (5) and (6) include a full set of age dummies. All standard errors, in parenthesis, are clustered at the province-year level. Significance levels: *** = 1%; ** = 5% and * = 10%.

Table 5: Some Robustness Checks of the Impact of Prices on C-section rates

	Price Ratio (CS/VD)		Price Gap (CS - VD)/100 ($2002)	
	(1)	(2)	(3)	(4)
Excluding malpresentations, Multiple births and previous C-sections N = 3 962 912	0.050*** (0.008)	0.049*** (0.008)	0.015*** (0.002)	0.014*** (0.002)
Mothers <40 years old N = 4 721 251	0.060*** (0.010)	0.058*** (0.011)	0.014*** (0.002)	0.014*** (0.003)
Mother < 35 years old N = 4 042 480	0.058*** (0.009)	0.056*** (0.011)	0.014*** (0.002)	0.014*** (0.003)
Probit Marginal effects N = 4 846 847	0.250*** (0.041) 0.053***	0.250*** (0.048) 0.054***	0.055*** (0.010) 0.012***	0.055*** (0.011) 0.012***
Province specific time trends N= 4 846 847	-0.001 (0.017)	-0.001 (0.018)	0.001 (0.004)	-0.000 (0.005)
Province controls		✓		✓
Province FE	✓	✓	✓	✓
Year FE	✓	✓	✓	✓

Notes: Province controls include: women's unemployment rate, proportion of women with a university degree, proportion of women without a high school degree, proportion of women physicians, supply of nurses, population growth, dummy variable for legislation over midwifery. All columns include a full set of age dummies. All standard errors, in parenthesis, are clustered at the province-year level. Significance levels: *** = 1%; ** = 5% and * = 10%.

Table 6: The Impact of Prices on C-section rates, Results by Physician Specialty

	Baseline Full Sample	GPs only	OB/GYNs only	Full Sample	Full Sample
	(1)	(2)	(3)	(4)	(5)
Price ratio (CS/VD)	0.056***	-0.027	0.078***	0.007	-0.196
	(0.011)	(0.025)	(0.022)	(0.042)	(0.461)
OB/GYN				0.268***	0.169
				(0.008)	(0.107)
OB/GYN x Price ratio					0.314***
					(0.041)
Multiple pregnancy	0.144***	0.152***	0.089***	0.100***	0.116***
	(0.005)	(0.015)	(0.006)	(0.006)	(0.006)
Fetus malpresentation	0.469***	0.185***	0.447***	0.428***	0.437***
	(0.007)	(0.012)	(0.007)	(0.008)	(0.008)
Pre-term	0.010***	-0.017***	-0.033***	-0.031***	-0.014***
	(0.002)	(0.002)	(0.003)	(0.003)	(0.001)
Post-term	0.055***	0.003***	0.038**	0.031***	0.055***
	(0.001)	(0.001)	(0.002)	(0.002)	(0.002)
Operative delivery	-0.217***	-0.038***	-0.318***	-0.265***	-0.233***
	(0.002)	(0.003)	(0.007)	(0.009)	(0.003)
Induced labor	-0.003	-0.003	-0.075***	-0.061***	-0.012***
	(0.002)	(0.003)	(0.004)	(0.004)	(0.001)
Previous C-section	0.561***	0.487***	0.537***	0.522***	0.283***
	(0.007)	(0.013)	(0.008)	(0.008)	(0.016)
Proportion of women physician	-0.002	-0.252	-1.033*	-0.091	0.006
	(0.061)	(0.106)	(0.845)	(0.226)	(0.091)
Ratio GPs/SPs	0.016	0.005	0.062**	0.079**	0.079***
	(0.010)	(0.003)	(0.023)	(0.031)	(0.018)
Province controls	✓	✓	✓	✓	✓
Province FE	✓	✓	✓	✓	✓
Year FE	✓	✓	✓	✓	✓
Observations	4 846 847	1 283 441	3 563 406	4 846 847	4 846 847
R^2	0.351	0.150	0.343	0.377	0.378

Notes: Province controls include: women's unemployment rate, proportion of women with a university degree, proportion of women without a high school degree, proportion of women physicians, supply of nurses, population growth, dummy variable for legislation over midwifery. All columns include a full set of age dummies. All standard errors, in parenthesis, are clustered at the province-year level. Significance levels: *** = 1%; ** = 5% and * = 10%.

Table 7: the Impact of Prices on C-section rates: Results by Physician Specialty (excluding all births for which there was a transfer from a GP to an OB/GYN)

	Full Sample	GPs only	OB/GYNs only
	(1)	(2)	(3)
Price ratio (CS/VD)	0.062***	-0.027	0.080***
	(0.003)	(0.018)	(0.018)
Multiple pregnancy	0.147***	0.152***	0.108***
	(0.001)	(0.015)	(0.006)
Fetus malpresentation	0.465***	0.185***	0.466***
	(0.001)	(0.012)	(0.007)
Pre-term	0.009***	-0.017***	0.001
	(0.001)	(0.002)	(0.002)
Post-term	0.051***	0.003***	0.067***
	(0.001)	(0.001)	(0.002)
Operative delivery	-0.213***	-0.038***	-0.272***
	(0.001)	(0.003)	(0.006)
Induced labor	-0.006***	-0.003	-0.019***
	(0.001)	(0.003)	(0.002)
Previous C-section	0.541***	0.485***	0.544***
	(0.007)	(0.017)	(0.008)
Proportion of women physician	-0.515	-0.252	-0.843***
	(0.380)	(0.106)	(0.202)
Ratio GPs/SPs	0.018***	0.005	0.053**
	(0.003)	(0.003)	(0.019)
Province controls	✓	✓	✓
Province FE	✓	✓	✓
Year FE	✓	✓	✓
Observations	4 701 068	1 283 441	3 425 128
R^2	0.330	0.150	0.315

Notes: Province controls include: women's unemployment rate, proportion of women with a university degree, proportion of women without a high school degree, proportion of women physicians, supply of nurses, population growth, dummy variable for legislation over midwifery. All columns include a full set of age dummies. All standard errors, in parenthesis, are clustered at the province-year level. Significance levels: *** = 1%; ** = 5% and * = 10%.

Appendix A: Additional Summary Statistics from the HMDB records

As a complement to Table 3, Table A.l presents a list of summary statics taken over the full sample of mothers for all ten provinces, between 1994 and 2010.

Table A.l: Summary statistics (Full sample)

	Mean	S.D.	Minimum	Maximum
Age	28.98	5.585	14	60
Age > 40 yrs	0.026	0.159	0	1
Age > 35 yrs	0.166	0.372	0	1
Postsecondary schooling	0.506	0.0647	0	1
Schooling < 8 yrs	0.020	0.008	0	1
Married mothers	0.665	0.103	0	1
C-section delivery	0.236	0.425	0	1
Imperative C-section	0.051	0.221	0	1
Length of inpatient stay	2.697	2.731	1	508
Inpatient stay > 1 month	0.001	0.038	0	1
Multiple birth	0.014	0.118	0	1
Fetus malpresentation	0.071	0.256	0	1
Pre-term delivery	0.089	0.285	0	1
Post-term delivery	0.103	0.304	0	1
Previous C-section	0.113	0.317	0	1
Operative delivery	0.119	0.324	0	1
Induced labor	0.196	0.397	0	1
Week-end delivery	0.227	0.419	0	1
Observations				4 846 847

Appendix B: Practice Guidelines, Policy Statements and Consensus Statements by the Society of Obstetricians and Gynaecologists of Canada

Concerned by the high C-section rates observed across the country in the mid 1980s, the Canadian medical community organized the 1985 National Consensus Conference on Aspects of Caesarean Birth to propose guidelines on the safest birth delivery methods for mothers' and infants' health, while limiting recourse to unnecessary surgery (SOGC 1986). Despite this initiative, C-section rates in Canada remained high and started rising steadily in the mid 1990s and through the 2000s. Trying to curb this trend, the Society of Obstetricians and Gynaecologists of Canada published a series of practical guidelines and policy statement to delimit the circumstances in which C-sections should be performed, most of which are described in List B.1.

In 2004, the SOGC reiterated that no evidence supported the idea that C-sections are less risky for mothers and newborns than vaginal deliveries. The association also highlighted that surgical deliveries are associated with risks (maternal and fetal respiratory distress, hemorrhage, lacerations, longer inpatient stay, complications such as placental insufficiency and uterine rupture in subsequent pregnancies, etc.) that should not be overlooked (SOGC 2004a, Leon et al. 2011). These guidelines are aligned with most of the American and European medical literature listing the risks and advantages of surgical deliveries compared to vaginal deliveries and documenting the circumstances under which C-sections should be considered.[34]

[34] A few studies explore why these medical guidelines discouraging the recourse to unnecessary C-sections have had so little influence on physicians' choice of delivery method. In a randomized controlled trial led in Ontario, Lomas et al. (1991) look at the impact of medical opinion on the management of birth delivery for mothers with a previous C-section. They estimate that the production and diffusion of guidelines, audits and feedback reports are insufficient to increase the recourse to trial of labor. They however find that attempts of vaginal birth after C-section could increase by 46 to 85

List B.1: Selected policy guidelines 1994-2010

November 1995: Policy Statement on the Role of Obstetricians and Gynaecologists in Canada

This policy statement acknowledges the greater share of obstetric care undertaken by OB/GYNs, as other types of physicians have gradually left that type of practice. It explains how OB/GYNs should, in response to this trend, undertake more primary care activities, because the demand for consultations by OB/GYNs is, in certain regions, too low to maintain "the minimum number of obstetricians/gynaecologists (usually three or more) required to provide 24-hour consultant access". (SOGC 1995)

February 1997: Policy Statement on Midwifery

This policy statement supports the recognition of midwifery as a licensed profession providing child delivery services for uncomplicated pregnancies. It mentions the SOGC's opposition to home births and deliveries in birthing centers, and encourages the integration of midwives in health service teams in which they would have access to health care resources and act under the direction of the physician in charge of the clinical department of obstetrics. (SOGC 1997a)

December 1997: Policy Statement on Vaginal Birth After Previous Caesarean Birth

This policy statement rejects the idea that pregnancies following a caesarean section should automatically lead to a repeat caesarean section. It suggests that all obstetric care facilities should be able to provide women with the opportunity to attempt a vaginal delivery after a caesarean birth, while recognizing the importance of patient choice: "Full participation of the patient in these decisions is vital". (SOGC 1997b)

July 2000: Management of Twin Pregnancy

This consensus statement specifies the consensus on the conditions (mono amniotic twins and conjoint twins) under which a caesarean section is indicated before any trial of labor for twin pregnancies. (SOGC 2000)

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percent if physicians were exposed to those guidelines in the form of an opinion from influential practitioners, rather than through written reports. Goodrick and Salancik (1996) also argue that recourse to unnecessary C-sections would increase in the absence of institutional accountability regarding the choice of medical interventions or in the presence of contradicting opinions and guidelines, which would generate grey zones facilitating the use of physicians' discretionary power.

August 2004: Guideline for Operative Vaginal Birth

This guideline replaces Practice Guideline no15 by explicitly positioning c-sections and operative 52 deliveries as substitutes in case of a complicated second stage of labor. The choice between both procedures by the physician is to be guided by pregnancy-specific characteristics, without any general indication in favor of one versus the other. (SOGC 2004b)

December 2008: Joint Policy Statement on Normal Childbirth

This joint policy statement defines the concept of normal birth and mentions that a "vaginal birth following a normal pregnancy is safer for mother and child than a caesarean section". It states that "there should be a valid reason (evidence-based practice) to intervene in the natural process when labor and birth are progressing normally" and that "All pregnant and birthing women and their families should be able to make informed choices. All candidates for normal birth should be encouraged to pursue it". It finally discourages the practice of elective c-sections without medical indications: "A Caesarean section should not be offered to a pregnant woman when there is no obstetrical indication" (SOGC et al. 2008)

July 2009: Policy Statement on the Role of Obstetricians and Gynaecologists in Canada

This policy statement acknowledges the greater share of obstetric care undertaken by OB/GYNs as other types of physicians leave that type of practice. This trend led OB/GYNs to undertake more primary care activities, because the demand for consultations by OB/GYNs is, in certain regions, too low to maintain "the minimum number of obstetricians/gynaecologists (usually three or more) required to provide 24-hour consultant access". (SOGC 2009)

July 2009: Policy Statement on Midwifery

Recommending more collaboration between care providers (including midwives) in obstetrics, this policy statement supports better access for midwives to health care facilities and resources, more information to patients as to the birth delivery options and their respective risks and benefits s well as harmonization of obstetrical standards for care across health professionals. (SOGC and CAM 2009)

Appendix C: Additional results

We present three additional sets of results. First, table C.1 compares the estimates obtained using the linear in probability model with those obtained using a probit model. The latter—estimated using a full set of province controls, province fixed effects, year fixed effects and a set of age dummies—yields marginal effects that are qualitatively and quantitatively similar to the main results presented in column (3) of table 4.

In table C.2, we report the estimated coefficients obtained when the full set of age dummies in the main estimating equation is replaced by a set of dummy variables for different age groups. While most of the estimated effects are similar to those presented in table 4, this specification facilitates the investigation of the relationship between age and the probability of a C-section, all else equal. The results indicate that delayed motherhood increases the likelihood of giving birth by C-section, even when controlling for all the risk factors and characteristics (including those indicative of potential complications) listed in the patients' hospital records.

We finally explore the possibility that the capacity of physicians to respond to price incentives varies with patient characteristics and with certain features of the work environment in obstetric care that would affect the degree of information asymmetry between the patient and the provider. We specifically test if the recognition and regulation of midwifery by certain provincial governments between 1994 and 2010 has contributed to reduce the informational advantage of physicians by providing mothers with access to alternative birth delivery options. A physician induced demand model with imperfect asymmetry of information would predict that access to midwives' services may make it more difficult for

physicians to respond to price incentives. Empirically, the coefficient associated with the interaction term between the price variable and a dummy for the recognition and regulation of midwifery is expected to be negative.

We simultaneously test if the informational advantage of a physician is increasing in his patient's age. Especially if they are averse to risk, older women, who face higher risk of complications at delivery, may be more inclined to follow physicians' advice to opt for a C-section.[35] This could provide the physician with greater scope to respond to higher relative compensation for C-sections. Empirically, this would result in a positive coefficient associated with an interaction term between the price variable and maternal age.

Table C.3 presents, in columns (4) to (6), the coefficients estimated using a version of the main estimating equation, augmented with the two interaction terms described above. A first observation is that the inclusion of those interaction terms does not alter substantially the estimated coefficients on the non-interacted variables of the model. Moreover, the price variable is still associated with a positive and significant impact on the probability of C-section, and that impact is slightly stronger than in the model without interactions (those results are reproduced in columns (1) to (3)).

Most importantly, the coefficients associated with the two interaction terms, reported in columns (4) to (6), move in the expected direction. The coefficient on the interaction term between the price incentive and the availability of midwifery as an alternative to physician services at birth delivery is negative, although not

[35] In the physician induced demand framework, this could be interpreted as these mothers having an inelastic or even positive elasticity of the demand for a physician's service with respect to his propensity to perform C-sections.

significantly different from zero. This result nonetheless qualitatively supports the idea that limiting the asymmetry of information between a physician and his patient by providing the latter with more information on alternative birth delivery methods may limit physicians' scope to respond to price incentives. The interaction term between the price incentive and the dummy variable indicating that a mother is older than 34 is, as hypothesized, associated with a positive coefficient. In the probit estimation, this estimated impact is significantly different from zero, suggesting that physicians may have a greater capacity to respond to price incentives when their patient is 35 years of age or more.

Table C.l: Impact of Prices on C-section Rates, Probit results

	LPM	Probit	
	Coefficients	Coefficients	Marginal effects
	(1)	(2)	(3)
Price ratio (CS/VD)	0.056***	0.250***	0.053***
	(0.011)	(0.062)	
Multiple birth	0.144***	0.545***	0.123***
	(0.004)	(0.193)	
Fetus malpresentation	0.469***	1.628***	0.503***
	(0.007)	(0.023)	
Preterm birth	0.010***	0.056***	0.010**
	(0.002)	(0.008)	
Post term birth	0.055***	0.241***	0.046***
	(0.001)	(0.005)	
Operative delivery	-0.217***	-1.786***	-0.134***
	(0.002)	(0.053)	
Induced labor	-0.003	-0.043	-0.007
	(0.002)	(0.027)	
Previous C-section	0.561***	1.767***	0.535***
	(0.007)	(0.019)	
Province Controls	✓	✓	✓
Province FE	✓	✓	✓
Year FE	✓	✓	✓
Age FE	✓	✓	✓
Observations	4 846 847	4 846 847	4 846 847

Notes: Province controls include: women's unemployment rate, proportion of women with a university degree, proportion of women without a high school degree, proportion of women physicians, supply of nurses, population growth, a dummy variable for the legal status of midwifery. All standard errors, in parenthesis, are clustered at the province-year level. Significance levels: *** = 1%, ** = 5% and * = 10%.

Table C.2: Impact of Prices on C-section Rates, Age Category dummies

	Price ratio (CS/VD)		Price gap (CS-VD)/100 ($2002)	
	(1)	(2)	(3)	(4)
Price incentive	0.060***	0.056***	0.014***	0.014***
	(0.009)	(0.010)	(0.002)	(0.003)
Multiple pregnancy	0.144***	0.144***	0.144***	0.144**
	(0.005)	(0.004)	(0.005)	(0.004)
Fetus malpresentation	0.469***	0.469***	0.469***	0.469***
	(0.007)	(0.007)	(0.007)	(0.007)
Age < 20	-0.019***	0.019***	-0.019***	-0.019***
	(0.001)	(0.001)	(0.002)	(0.001)
Age 20-24	-0.014***	0.014***	-0.014***	-0.014***
	(0.001)	(0.001)	(0.001)	(0.001)
Age 30-34	0.008***	0.008***	0.008***	0.008***
	(0.001)	(0.001)	(0.002)	(0.001)
Age 35-39	0.029***	0.0029***	0.029***	0.029***
	(0.001)	(0.001)	(0.001)	(0.001)
Age > 40	0.073***	0.073***	0.073***	0.073***
	(0.002)	(0.002)	(0.001)	(0.002)
Pre-term	0.010***	0.010***	0.010***	0.010***
	(0.002)	(0.003)	(0.002)	(0.002)
Post-term	0.054***	0.055***	0.055***	0.055***
	(0.001)	(0.002)	(0.001)	(0.001)
Operative delivery	-0.217***	-0.216***	-0.217***	-0.217***
	(0.002)	(0.002)	(0.002)	(0.002)
Induced labor	-0.003	-0.003	-0.003	-0.003*
	(0.002)	(0.002)	(0.002)	(0.002)
Previous C-section	0.561***	0.561***	0.561***	0.561***
	(0.007)	(0.007)	(0.007)	(0.007)
Province controls		✓		✓
Province FE	✓	✓	✓	✓
Year FE	✓	✓	✓	✓
Observations	4 846 847	4 846 847	4 846 847	4 846 847
R^2	0.298	0.327	0.304	0.346

Notes: Province controls include: women's unemployment rate, proportion of women with a university degree, proportion of women without a high school degree, proportion of women physicians, supply of nurses, population growth, a dummy variable for the legal status of midwifery. The omitted category for age groups is 25-29. All standard errors, in parenthesis, are clustered at the province-year level. Significance levels: *** = 1%, ** = 5% and * = 10%.

Table C.3: Impact of Prices on C-section Rates, With Interaction Terms

	LPM	Probit		LPM	Probit	
	Coefficients	Coefficients	Marginal effects	Coefficients	Coefficients	Marginal effects
	(1)	(2)	(3)	(4)	(5)	(6)
Price ratio (CS/VD)	0.056*** (0.010)	0.250*** (0.062)	0.053***	0.066*** (0.014)	0.274*** (0.063)	0.056***
Price ratio x Age > 34				0.021 (0.007)	0.057** (0.024)	0.020**
Price ratio x Midwifery				-0.003 (0.023)	-0.105 (0.093)	-0.018
Multiple birth	0.144*** (0.004)	0.545*** (0.193)	0.123***	0.144*** (0.005)	0.549*** (0.152)	0.136***
Festus malpresentation	0.469*** (0.007)	1.628*** (0.023)	0.503***	0.469*** (0.007)	1.628*** (0.023)	0.503***
Previous C-section	0.561*** (0.007)	1.767*** (0.019)	0.535***	0.561*** (0.007)	1.759*** (0.020)	0.531***
Preterm birth	0.010*** (0.002)	0.056*** (0.008)	0.010**	0.008*** (0.002)	0.055*** (0.009)	0.010**
Post term birth	0.055*** (0.001)	0.241*** (0.005)	0.046***	0.055*** (0.001)	0.241*** (0.005)	0.048**
Operative delivery	-0.217*** (0.002)	-1.786*** (0.053)	-0.134***	-0.217*** (0.002)	-1.786*** (0.053)	-0.134***
Induced labor	-0.003* (0.002)	-0.043 (0.027)	-0.007	-0.003 (0.002)	-0.043 (0.031)	-0.004
Midwifery regulated	-0.001 (0.001)	-0.007 (0.154)	-0.001	-0.033* (0.020)	-0.122 (0.099)	-0.002
Age > 34				0.028* (0.019)	0.197** (0.009)	0.031***
Province Controls	✓	✓	✓	✓	✓	✓
Province FE	✓	✓	✓	✓	✓	✓
Year FE	✓	✓	✓	✓	✓	✓
Age group FE	✓	✓	✓	✓	✓	✓
Observations	4 846 847	4 846 847	4 846 847	4 846 847	4 846 847	4 846 847

Notes: Province controls include: women's unemployment rate, proportion of women with a university degree, proportion of women without a high school degree, proportion of women physicians, supply of nurses, population growth. All standard errors, in parenthesis, are clustered at the province-year level. Significance levels: *** = 1%, ** = 5% and * = 10%.