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The Effect of Physician Fees and Density Differences on Regional Variation in Hospital Treatments

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Abstract

We use a panel data set of about 1.7 million hospital records in 4,000 Dutch zip code regions for the years 2006-2009. We estimate the effect of physician fees and physician density on regional variation in hospital care for nine different treatments. Our results show that a 1 percent increase in the total number of physicians, if these extra physicians are all paid according to an output-based reimbursement scheme, would increase the number of treatments on average by 0.40 percent. For salaried physicians we find a significantly lower average effect of 0.15 percent. We find no or weak effects for hip fractures, which is included in the analysis as a control treatment. Our data allows us to deal with reverse causality, excess demand, border crossing, and availability effects. Our findings lend support to the existence of supplier induced demand for the majority of the analyzed treatments.

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1. Introduction

The causes and consequences of regional variation in hospital treatments have long been researched in the health economics literature over the last decades (Skinner, 2011). A large variation across geographical areas may be unwarranted if this is caused by utility maximizing behavior of physicians or hospitals responding to financial incentives. This problem is often referred to in the literature (e.g. Evans, 1974, McGuire 2008) as "supplier induced demand" (SID). SID may make the achievement of controlling costs in health care problematic since possible efficiency gains by an increase in labour productivity may be offset through an increase in the production of less beneficial treatments. SID may be unwarranted if it leads to treatments that add no additional benefits to patients. This is what many economists also call the "flat of the curve medicine" (Getzen, 2006).

The goal of our paper is to empirically test whether differences in physician fee structures and physician density can explain regional variation in hospital treatments in the Netherlands. We use a panel data set of about 1.7 million hospital records in 4,000 Dutch zip code regions for the years 2006-2009. We estimate the effect of physician fees and physician density on regional variation in hospital care for nine different treatments. In our dataset 75 percent of the physicians are paid with an output based reimbursement scheme with a fee for each delivered treatment ('fee-for-treatment' or FFT physicians). The other 25 percent of the physicians is salaried, i.e. receives a fixed wage. Our data allows us to exactly identify border crossing of patients across geographical regions and which enables us to allocate physicians to a geographical region in proportion to their workload for that region.

Our empirical paper belongs to the strand of the literature that relates geographical variation to demand and supply factors (Wennberg, 2010, Skinner, 2011) and the traditional literature that tests for SID (such as Fuchs, 1978; Cromwell and Mitchell, 1986; Dranove and Wehner, 1994; Delattre and Dormont, 2003). Chandra et al. (2011) further state that "the role of fee differences in explaining different treatments across patients or areas is unknown". We fill this gap of the literature by looking at the Dutch hospital sector that has been liberalized since 2000 and shows an annual growth rate of more than 7 percent. Fee differences among physicians allow us to test our *ex-ante* hypothesis that if inducement occurs, then this effect will be stronger for FFT physicians than salaried physicians. We test this hypothesis for different hospital treatments belonging to different specialisms. Our contribution to the literature is the use of a large panel data set that covers the Dutch population over four consecutive years. By using fixed effect estimations we are able to better control for geographical variations in supply and demand, and obtain more reliable estimates for our supply side effects than previous papers.

We find that, on average, the number of treatments is higher in areas where patients visit relatively more FFT physicians. We also find that in those areas with higher physician density patients are more often treated. This effect is also stronger for FFT physicians. For salaried physicians the effect is smaller but not absent. We argue that this positive effect may be related to the incentives of the hospital management that rewards higher productivity. Within the category salaried physicians we distinguish between physicians working in university hospitals (UH physicians) and general hospitals (GH physicians). Our study does not indicate strong significant differences between the latter two types of physicians. Our results indicate the existence of SID. However, we cannot conclude that this inducement is undesirable.

The article is organized as follows: section 2 discusses the literature on regional variation and our contribution to it. Section 3 briefly describes the institutional setting of the Dutch hospital market. Our data and descriptive statistics are presented in section 4. Section 5 describes our econometric methods and empirical results. Section 6 reports various robustness analyses and section 7 concludes.

2. The literature on regional variation and our contribution

There are numerous papers that study the causes of regional variation and SID; a recent overview on regional variation is provided by Skinner (2011). McGuire (2000, 2008) lists the theoretical and empirical literature on SID, and Leonard et al. (2009) perform a systematic literature review. In this section, therefore, we will briefly discuss some influential papers and explain how we contribute to the empirical literature.

Empirical studies relate patient treatment to demand variables — such as patient characteristics, medical need and demand price — and to supply factors — such as physician density, number of hospital beds or supply price. Skinner (2011) explains possible causes related to regional variation in hospital utilization. An important conclusion is that the size of the variation is related the type of treatment. Some treatments show a small variation across regions while others, such as surgical and other preference-sensitive procedures, show a much larger variation.

The first seminal paper on SID is usually associated to Evans (1974) and the first influential empirical paper is Fuchs (1978) who shows that physicians have a preference for living in certain geographical areas. He uses this variation in surgeon density to test for SID. His findings are that a 10 percent increase in the physician density ratio results in a 3 percent increase in medical per-capita utilization. Cromwell and Mitchell (1986) follow up on Fuchs' study and use to a large extent the same data source. The authors find smaller effects of about one third compared to Fuchs. In both US studies the price elasticity of demand plays an important role that complicates the identification of SID. In our study price plays a minor role since Dutch consumers are fully insured and face low cost sharing arrangements. Moreover, also on the supply side price plays a minor role. The production incentives for Dutch physicians depend weakly on price because physicians receive an hourly tariff for each treatment that varies little across specialties.

Another interesting paper is Grytten and Sørensen (2001) who compare two groups of physicians facing different financial incentives. The authors do not find evidence for SID in either group. Delattre and Dormont (2003) use panel data on French physicians and find strong evidence for SID; they conclude that a 1 percent increase of physician density leads to a growth of aggregate expenses of about 0.5 percent.

Data availability is one of the main problems when studying regional variation, and SID in particular. The existing literature on SID mainly collected data from surveys. In this context, it is interesting to pinpoint that also the Dartmouth Atlas of Health Care (www.darthmouthatlas.org) does not cover all medical treatments in the US but only those belonging to the insurance program Medicare. An important advantage of our study is that we have data for all Dutch patients on nine different hospital treatments.[1]

Pomp (2009) made a first attempt to test for SID in the Dutch hospital market for several treatments. His empirical results are mixed and the estimated effects are rather small.[2] He concludes that salaried physicians do not reveal any indication of SID but some FFT physicians might be more sensitive to it.

[1] The nine treatments are: cataract (ophthalmology), tonsillectomy (otolaryngology), hernia (neurology), varicose veins (dermatology and surgery), inguinal hernia (surgery), hip arthrosis (orthopedics), knee arthrosis (orthopedics), hip fracture (surgery).

[2] Our study is an improvement on Pomp (2009) because we collect two additional years of hospital data, recent information on the number of physicians, and demand factors such as availability data and hospital waiting time. Furthermore, we improve on his estimation procedure by using panel data techniques.

In this study we relate treatment density to physician density in all Dutch zip code areas for the years 2006 to 2009.[3] We control for possible differences in the demand for health care between zip codes by including several socio-demographic and population health-related factors. This setup is the general point of departure when measuring supply side effects. The next steps are, however, less clear but extensively discussed in the literature. We will discuss these steps hereafter and explain how we deal with potential difficulties.

One of the most prominent issues to tackle is reverse causality. The observed positive correlation between physician density and per-capita healthcare utilization may be due to other factors rather than SID alone. Physicians may settle down in geographical areas where demand is high. Dranove and Wehner (1994) show for example the existence of SID for childbirths. The authors state that their finding may be related to an incorrectly specified demand or physician supply equation. We address the problem of reverse causality in three different ways. First, we use panel data to control for unobserved heterogeneity in demand or supply factors across geographical areas. Second, we exploit instrumental variables to control for possible endogeneity. But more importantly, we exploit the data on different fee structures and treatments. Our *ex-ante* hypothesis is that FFT physicians have a stronger incentive to deliver care than salaried physicians because both the hospital management and the physician can increase their turnover by expanding the number of treatments. We expect *ex-ante* no support for SID for some treatments, such as hip fractures, while for other treatments, such as tonsillectomies and cataracts, demand inducement may occur.

A second empirical issue is related to border crossing (Skinner, 2011). The main concern is the construction of the physician's density variable, i.e. how to allocate the number of physicians to geographical regions if patients visit hospitals, and physicians treat patients, outside their own region. Our dataset allows us to tackle this problem by exploiting zip code information of both the patient and the visited hospital. The allocation of a physician to a region is determined by his percentage workload for that region. We will explain this procedure more thoroughly in section four.

A third empirical problem concerns the alleged existence of excess demand (Zweifel et al., 2009). If there is only excess demand but no demand inducement, we should observe a positive (and proportional) correlation between physician density and hospital services at

[3] There are approximately 4,000 four-digit zip code areas in the Netherlands.

low physician densities. However, as of 2001, Dutch hospital production increased strongly as the budget system for hospitals was abolished and hospital financing was, at least for the treatments we consider, to a large extent volume-based and open-ended. After 2001 waiting times in Dutch hospitals dropped considerably and this reduces the chance that excess demand plays a role in our analysis (Van de Vijsel et al., 2011). For some treatments waiting lists still exist and we use the available waiting time information of individual hospitals to control for excess demand in our estimations.

A fourth well-known empirical problem is the availability effect (Zweifel et al., 2009). The growth of service volume associated with increasing physician density can be the result of demand decisions by rational patients. For example, an increase in the availability of physicians, through the opening of new hospitals or clinics, could reduce the non-financial cost of patients in terms of travel time and/or making an appointment. Although this problem seems to be much smaller in a strongly urbanized and flat country as the Netherlands, we control for this by including in our model several variables related to health care availability such as the number of hospitals located within twenty kilometers of each zip code area, the number of general practitioners (GPs) within three kilometers in each zip code area, the distance to the closest GP, and the distance to the closest GP center. The latter three variables may control for referral patterns of GPs.

To summarize, we expect that FFT physicians are more prone to demand inducement than salaried physicians. Our *ex-ante* expectation is that demand inducement is small or non-existent for clear-cut and/or medical risky treatments, such as hip fractures, but larger for treatments with low medical risks and for which there is considerable variation in the use of medical procedures, such as cataracts and tonsillectomies. Our dataset allows us to control for potential problems as reverse causality, excess demand, border crossing, and availability effects.

3. Institutional setting

The institutional and regulatory framework of a health care system influences the incentives of both physicians and patients and, hence, the scope for SID (Bickerdyke et al., 2002). In this section we explain the institutional and regulatory background in which Dutch hospitals operate. Several institutional factors between 2006 and 2009 make the Dutch healthcare system susceptible to SID.

Dutch consumers are almost fully insured and there are only few incentives for patients to restrain demand.[4] For hospital care consumers face a non-monetary constraint since, with the exception of emergency care, access to hospitals takes place only upon GP referral.[5] During 2006-2009 almost all patients could freely choose their preferred hospital.[6] Patients may thus demand services that provide only a small benefit relative to the costs borne by the insurer. As a result, the Dutch insurance system with nearly complete coverage makes it attractive for physicians to induce demand, as they know patients will have only minor payment concerns.

The government opted to liberalize the provision of health care, including the provision of hospital services. Hospitals are all not-for profit and were historically financed with budgets. In 2001 the strict budgets were replaced by volume based and open-ended budgets, in which "money follows the patients". In 2005 a new hospital payment system called 'Diagnosis Treatment Combination' (DTC) was implemented. Unlike DRG's, a DTC is not based on the diagnosis of discharge, but relies on an episode-based registration within hospitals. A unique characteristic of the DTC system is the absence of DTC coders, i.e. physicians register DTC's themselves and can change the DTC registration during the treatment process (Steinbush et al., 2006). The introduction of the DTC system should facilitate the role of insurers as purchasers of care. In 2005, hospitals received a fixed, centrally determined price for initially 90 percent of the DTC's (the so-called Part A). The remaining 10 percent (part B) was left to negotiations on volume and price between health insurers and hospitals. Part B was extended from 10 percent in 2005 to 34 percent in 2009.[7]

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[4] Dutch citizens pay only 5 percent of their health care expenditures out-of-pocket, which is one of the lowest contribution in comparison with other EU member states (European Commission, 2010). During the sample period the annual mandatory deductible for basic benefit package was €150 euro for adults (and €0 for children). Adults can choose for an additional voluntary deductible up to €500, but only about 5 percent of the population opted for such an additional deductible (NZa, 2011).

[5] About 63 percent of the patients in Dutch hospitals are referred by a GP. This figure was quite stable over the past years. However, the figure declined to 57,7% in 2008 and 60.6% in 2009 (CBS, 2011), suggesting that physicians increased the number of referrals to other physicians (or to themselves) within hospitals.

[6] The health care sector in the Netherlands has been fundamentally reformed in 2006 with the introduction of regulated competition (Van de Ven and Schut, 2008). The rationale behind the reform is to introduce competition in health care to stimulate efficiency and to curb health care costs while at the same time safeguarding government objectives such as affordability, quality, and physical accessibility. During 2006-2009 there was one small insurer that started to experiment with selective contracting of hospitals.

[7] Part B is expanded to 70 percent in 2012.

For our research it is important to note that eight of our treatments belong to part B, and only hip fractures belongs to Part A.

Dutch physicians are either self-employed professionals organized by specialty in partnerships (FFT physicians) or they receive a fixed salary from the hospital (European Observatory, 2010). After the introduction of DTC's in 2005 FFT physicians receive a fixed fee for every treatment.[8] Each DTC is characterized by a code that contains a normative time spent by the physician and an hourly tariff set by the Dutch Healthcare Authority (NZa). The income earned by FFT physicians is mainly determined by their production. The financial incentives for FFT physicians and the hospital management are aligned since the hospital can increase its turnover as well by treating more patients.

Salaried physicians receive a monthly fixed wage irrespective of their production. In this research we will distinguish two types of salaried-physicians: those who are employed at university hospitals (UH physicians) and those who work at general hospitals (GH physicians). The hospital management has production incentives too and may reward more treatments, e.g. by providing additional bonuses to salaried physicians or other type of secondary benefits. Salaried physicians may thus face incentives to deliver more treatments too. Our *ex-ante* hypothesis is that the existence of different types of physicians leads to different incentives, since only FFT physicians can *de facto* increase their own income directly by delivering more treatments.[9]

Between 2006 and 2009 there were 8 university hospitals and 2 specialty hospitals. In 2006 there were 88 general hospitals and that number decreased to 85 in 2009 due to mergers (NZa, 2010 and 2011). The liberalization of the hospital market led to a concentrated market of general hospitals and to a fast growth of private clinics, which are often affiliated to a hospital. The number of private clinics increased from 37 in 2005 to 129 in 2009. Private clinics operate only in part B of hospital care and they account for about 6 percent of the delivered care in part B (NZa, 2010). The increased production in private clinics is partly responsible for the movement of physicians from general hospitals to private

[8] A DTC can be characterized as a bundle of services. FFT physicians were present during the budgeting system before the year 2000, but this caused tension because the hospital management tried to restrict their activities (Kruijthof, 2005).

[9] Prior to 2008 medical specialists received a lump sum (fixed budget) payment in part A of hospital care. In each hospital the lump sum was divided among specialists according to past production and fees. As the lump sum was a fixed amount of money, there were no incentives for specialists to increase the production. The lump sum ceased to exist in 2008. Since then medical specialists face the same financial incentives in part A and part B of hospital care.

clinics in the market, which creates additional variation in the number of physicians across regions.

The rationale of the healthcare system is that insurers negotiate with hospitals on volume and quality, and in part B, also on price. Since the outcomes of price negotiations between hospitals and health insurers are private, there is only some general information available on a macro level. For example, monitoring reports of the Dutch Healthcare Authority (NZa) show that average prices of treatments in part B of healthcare somewhat dropped, especially in private clinics, but the total turnover of hospital care showed a stable annual growth during our sample period of about 7 percent (NZa, 2011). This figure corresponds to an average annual growth rate of hospital admissions during 2001-2009 of about 7 percent (CBS, 2011). In most industrialized countries a steady decrease of in-patient hospital admission rates is replaced by an increasing number of day care admissions. However, as Van de Vijsel et al. (2011) argue, the Netherlands did not quite follow this pattern. The authors show that after abolishing fixed budgets in 2001 in-patient admission rates increased by more than 3 percent per year during 2001-2007, while at the same time there was an explosive growth of day care admissions, of about 9 percent annually. A recent evaluation of the Dutch health care market concluded that health insurers are slowly beginning to learn how to negotiate with providers to obtain care at a discount (ZonMw, 2009). Also Boone et al. (2010) conclude that Dutch health insurers have just begun to invest in managed care activities. It is likely that it will take several more years before they are able to negotiate more aggressively with providers that have market power in the Netherlands.

The Dutch market reform has created strong incentives for FFT physicians and hospitals to increase delivered treatments. First, Dutch consumers face almost full insurance coverage with limited cost-sharing and free hospital choice. Second, the general impression is that the role of insurers to discipline hospitals and physicians has been rather limited, at least in the early years after the reform. Third, the FFT payment may have stimulated both physician and hospital production. These factors provide ample reasons to believe that SID might play a role in the Dutch hospital production during 2006-2009.

4. Data and descriptive statistics

Our analysis relies on three main data sources: the Dutch Healthcare Authority (NZa) for DTC information, Statistics Netherlands (CBS) for demographic and socio-economic factors, and Dutch Hospital Data (DHD) for information on physicians working in hospitals.

4.1 DTC-data and the construction of treatment density

DTC information is drawn from administrative data collected by the NZA (*DTC-informatiesysteem DIS*) and covers the period 2006 to 2009. Table 1-A provides a summary of the data. Our dataset includes 1,714,143 DTC's collected from all Dutch general and university hospitals and 78 private clinics. For each DTC information on the patients' age, gender, and the four-digit zip code of the place of residence is available as well as the zip code of the visited hospital. A DTC describes the total health care package and includes the diagnoses, which is closely linked to ICD-10 coding, the type of care that a patient receives, and the average treatment time that is needed for a physician. A DTC is opened at the first consult with the physician and is closed when the patient had his last examination.[10] We assign a treatment to the year in which the DTC is opened since about 75 percent of DTC´s is opened and closed during the same year.

We consider nine different hospital treatments within 6 different specialties. Each hospital diagnosis corresponds to a homogeneous group of unique DTC codes within a medical specialty. The treatments are chosen on the basis of their recurrence, their difference in diagnosis ambiguity and in medical risk.[11] Recurrence of DTC's is important to obtain enough power for our econometric tests, and the latter two aspects are important for the determination of our *ex-ante* expectations whether a treatment is supply sensitive. Appendix A provides information on the DTC codes and our *ex-ante* expectations in terms of diagnosis ambiguity and medical risk.

INCLUDE TABLE 1-A AROUND HERE

[10] DTC's have formally a maximum length of 365 days. For chronic patients DTC's are automatically closed after one year-period and reopened thereafter. Steinbusch et al. (2007) provide more information about DTC's and its relation to DRG's.

[11] Our aim is also to compare our outcomes with the research of Pomp (2009), who did not find strong evidence for SID.

Table 1-A reports the number of DTC's for each single year, the patient's average age, the percentage of men, the number of hospitals and private clinics performing this type of treatment, and the *ex-ante* expectation whether a treatment is supply sensitive. We have most observations for cataracts and tonsillectomies. People that undergo a cataract operation are on average seventy years old and mostly women. Tonsils are removed at an average age of ten. Varicose veins are treated within two different specialties. From an econometric point of view it is important to note that we have fewer observations for hip fractures. However, we decided to include hip fractures in our analysis to test our *ex-ante* hypothesis of no SID for this treatment (see also Wennberg, 2010).

Roughly 8 percent of our data contains incomplete DTC's. Some hospitals deliver incorrect information, such as wrong or non-existing zip codes. Since the zip code of a patient is crucial for our econometric analyses we deleted a two-digit zip code area when a hospital in that area entered wrong zip codes for more than 20 percent of its treatments in a given year.[12]

Our dependent variable, treatment density, is defined as the number of treatments in a four-digit zip code area divided by the population size.[13] This definition creates a panel data set that contains repeated observations for approximately 3,600 four-digit zip code areas for four consecutive years 2006 to 2009. For very small areas, treatment density shows a lot of variation and we are confronted with missing values and outliers.[14] According to Diehr et al. (1992) geographical areas should not be defined too small; therefore we excluded from our analysis all 4-digit zip code areas with less than 500 inhabitants. This corresponds to the loss of 1 percent of the total number of observations and the exclusion of about 850 four-digit zip code areas. The final analysis relies on about 2,750 remaining four-digit zip code areas. The descriptive statistics for treatment density are presented in table 1-B.

INCLUDE TABLE 1-B AROUND HERE

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[12] Especially in 2006 and 2008 many hospitals often used, for all nine treatments, the non-existing zip code "1000". In total there are 36 hospitals during 2006-2009 that entered for more than 20 percent of the DTC's a non-existing zip code. Computationally, we followed a similar procedure for all nine treatments and deleted approximately 400 four-digit zip code areas for which the first two-digits of the zip code are the same as that of the hospital.

[13] The number of inhabitants per four-digit zip code area is obtained from CBS (see section 4.2).

[14] The missing values refer to our explanatory variables that we obtained from the CBS (see section 4.2).

4.2 *Explanatory variables for demand*

From Statistics Netherlands (CBS) we collect demographic and socio-economic data at the four-digit zip code level.[15] These variables and their descriptive statistics are summarized in Table 2.

INCLUDE TABLE 2 AROUND HERE

We include several variables in our analysis that indirectly control for health status.[16] The first twenty variables in Table 2 reflect the age distribution for 5-year cohorts per four-digit zip code. Next, we include information on gender, and social and economic status of the population. About 15 percent of the population is non-native, and we distinguish between Western and non-Western immigrants.[17] We further include the income distribution of a zip code; this may be an important factor explaining health care utilization. We distinguish three classes: individuals belonging to the lowest 40 percent of the national income distribution, individuals belonging to the upper 20 percent of the national income distribution, and individuals between these two classes. CBS does not provide income data for the year 2008; therefore we construct income data for 2008 by taking the average of the years 2007 and 2009. We also include data on the working and self-employed population and people receiving social assistance. Data for 2009 is absent; therefore we use 2008 data as a proxy.[18] We include urbanization, defined as the number of addresses per square kilometer, of a zip code area as well. Each zip code area is categorized in five urbanization levels, where value 1 denotes the highest urbanization and 5 the lowest. Another factor influencing regional health care use is the regional mortality rate that is defined as the

[15] This information is freely available at www.cbs.nl.

[16] Variables that are directly related to health status are not necessarily preferable in explaining regional variation. Inhabitants are more likely to receive treatment when their physician treats them more intensively. This bias may make patients in high treatment areas appear sicker than they actually are.

[17] Western immigrants come from Europe, North America, Oceania, Indonesia and Japan. Non-western immigrants are from Africa, Turkey, Latin-America and Asia (except Japan and Indonesia).

[18] This data tends to be quite stable over time.

number of deceased per 1,000 inhabitants.[19] Mortality data for 2009 is absent; we use 2008 data as a proxy.

The number of treatments in a geographical area may be associated with the availability of health care. For example if the number of providers in an area increases, travel costs of patients decrease, thereby facilitating access to care. We include the number of hospitals within 20 km as a proxy for hospital availability, and average distance to the closest GP, the number of GPs within a radius of three kilometers, and the average distance to the closest GP center as proxies for GP availability. In the Netherlands GPs work as gatekeepers; patients need a referral before accessing the hospital. There are no monetary costs involved for visiting a GP practice. All these four factors are available for the years 2007 and 2008; because of their little variation over time we use the values of the years 2007 and 2008 as proxies for 2006 and 2009 respectively.

We control for excessive demand by using data on waiting times. Table 3 provides an overview of the waiting time data.

INCLUDE TABLE 3 AROUND HERE

Table 3 presents for each treatment the average waiting time (in number of weeks) for a hospital treatment. Waiting time data is available for almost all hospitals for six treatments. For hip fractures waiting time is less relevant since in many cases this is an emergency treatment. For the remaining two treatments, hernia (neurology) and varicose veins (dermatology) we could not obtain data. For our estimations we transform our waiting time data on individual hospitals to waiting time data on zip code areas. We apply the same methodology as with the allocation of physicians to zip code areas that will be explained in section 4.3.

4.3 Physician data and the construction of physician density

Data on the number of physicians comes from Dutch Hospital Data (DHD). For almost all general hospitals we have information on the number of physicians per specialty —

[19] Mortality rate can be viewed as an outcome indicator of health care performances. This is however less relevant for our analysis since our treatments are not life-threatening.

expressed in full time equivalents— and their type of remuneration (FFT vs. salary). Table 4-A reports the total number of physicians per specialty and remuneration scheme for the years 2006 to 2009.

INCLUDE TABLE 4-A AROUND HERE

We did not obtain physician data for all Dutch hospitals. In Appendix B we explain how we adjust the physician density for missing physician data for some hospitals and private clinics. Table 4-A shows that the majority of Dutch physicians are paid FFT (roughly 75 percent in our dataset).

We split salaried physicians into two categories: UH physicians treat on average fewer patients than GH physicians, presumably because they devote more time to schooling/education, research, and more complicated treatments. In our sample FFT physicians treat on average more patients than GH physicians (see last three columns of Table 4-A). This latter observation matches with Kruijthof (2005) who reports that FFT physicians make longer working hours, devote more time on treating patients and have less management responsibilities than GH and UH physicians. However, one could argue that this may also be the result of FFT physicians selecting favorable patients (Barro and Beaulieu, 2003); such as treating a higher proportion of short stay patients (Wright, 2007).

One of the main challenges in the literature on regional variation is the allocation of physicians to geographical areas. The number of physicians of the nearest hospital may not be an adequate measure of physician density because patients may cross regional borders and choose other hospitals. This holds especially in the Netherlands where patients are free to choose their preferred hospital and distances between hospitals are relatively small. A common method is to minimize possible border crossing by carefully constructing hospital service areas (Wennberg, 2010). This method is complicated for a strongly urbanized country with a high population density as the Netherlands. Although most patients visit a hospital close to their place of residence, (specialized) hospitals attract patients from all over the country. In this paper we base service areas on administrative borders and define them as two-digit zip code areas[20]. We address the issue of border crossing by proportionally allocating physicians to service areas according to their workload in that area. The following example illustrates this. If a physician treats 10 percent of his patients in a certain service area then this service area gets 10 percent of full-time work equivalent of the physician. In principle this allocation procedure works for any kind of predefined service area. Using two-digits zip codes to define service areas results in a total number of 90 service areas; this is somewhat lower than the number of Dutch hospitals. The average population size of the two-digit service area is about 150,000. We refer to Appendix B for an in-depth exposition of the calculation of physician density.

The descriptive statistics for physician density are presented in Table 4-B and 4-C. As we apply panel data techniques, it is important that the physician density variables show enough within variation. Table 4-C confirms this. Possible reasons for the observed within variation are the general increase in the number of physicians, but the increase in the number of private clinics might play a role as well. The increased production in private clinics has presumably led to a movement of physicians from general hospital to private clinics, leading to a changing composition of the physician workforce in our service areas.

In Table 4-D we show statistics about the percentage of physicians (per type of physician) that patients visit in two-digits zip code areas. This provides some information on our data limitations. For example, the number of missing or unknown physicians (UN-physicians) is about 15 percent. Only for varicose veins this is about 30 percent. Recall that the majority of UN-physicians are working in private clinics. We will use the information in Table 4-D in the robustness analyses in section 6.

INCLUDE TABLE 4-B, 4-C and 4-D AROUND HERE

[20] A two-digit zip code area is a set of four-digit zip codes that is uniquely determined by its first two-digits. Large service areas are also necessary to avoid the risk of yielding a positive correlation between physician density and treatment density simply by construction. This may occur if the number of observations for a treatment is relatively small.

5. Estimation results

5.1 Estimation of demand and physician density

We follow the literature on small area variation and estimate for each of the nine treatments a demand and supply equation of the following form [1][21]. Our general specification is similar to Fuchs (1978), Cromwell and Mitchell (1986) and Dranove and Wehner (1994) but we additionally include random or fixed effects α_i:[22]

$$y_{it} = \alpha_i + \gamma_t + \delta_{UH} x_{UH,it} + \delta_{GH} x_{GH,it} + \delta_{FFT} x_{FFT,it} + Z_{it}^{'} \beta + \varepsilon_{it}. \qquad [1]$$

$x_{\theta,it}$ represents the physician density of type $\theta \in \{\mathrm{GH}, \mathrm{UH}, \mathrm{FFT}\}$ and δ_θ is our parameter of interest that should indicate if SID might play a role. The random or fixed four-digit zip code specific effects are denoted by α_i. The standard errors ε_{it} are robust for heteroskedasticity and serial correlation (i.e. standard errors are clustered by zip code area). We estimate equation [1] with pooled OLS, random and fixed effects. Possible endogeneity problems will be addressed in section 5.2.

We are interested in the ceteris paribus effect of physician density on the number of treatments, if the total number of physicians increases by 1 percent. To obtain these semi-elasticities we compute the following after estimation:

$$\hat{\xi}_\theta = \frac{\hat{\delta}_\theta \sum_\theta \bar{x}_\theta}{\bar{y}}, \text{ where } \bar{x}_\theta \text{ is the average density of type } \theta.$$

This formulation rescales our estimated effects $\hat{\delta}_\theta$ to semi-elasticities $\hat{\xi}_\theta$ and allows us to better compare effects among different physician types θ. $\hat{\xi}_\theta$ can be interpreted as the percentage change in the total number of treatments due to a 1 percent increase in the total number of physicians, given that all extra physicians are of type θ only.

We use these semi-elasticities to test two hypotheses. First, we test whether increasing the number of physicians results in more treatments. In that case we have a first indication

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[21] In Appendix C we estimate the same equation without supply side factors. We show that the unexplained variation is not randomly distributed either over time or across regions.

[22] As we explained in section 3 we do not take price variables into account because Dutch patients are fully insured for hospital treatment and FFT physicians face little variation in the hourly tariffs per treatment.

for SID. Further, if this occurs, we expect the effect to be larger for FFT physicians than for GH and UH physicians.

HYPOTHESIS I. In case of SID: $\hat{\xi}_{FFT} > 0$ and $\hat{\xi}_{FFT} > \hat{\xi}_{UH}$ and $\hat{\xi}_{FFT} > \hat{\xi}_{GH}$.

Second, the *ex-ante* expectation is that more risky and/or more clear-cut/less ambiguous treatments are less vulnerable to SID than less risky and/or less cleat-cut/more ambiguous treatments (see table 1-A).

HYPOTHESIS II. $\hat{\xi}_{\theta}$ is lower for treatments with a lower *ex-ante* expected chance of SID.

Our estimation results for cataracts are presented in Table 5 (columns 2-4) and $\hat{\xi}_{\theta}$ in Table 7-A.[23] With the Breusch and Pagan Lagrange multiplier we test the RE model against the OLS model. At a significance level of 5 percent we reject the null hypothesis, which implies that we reject the OLS model in favor of the RE model for all treatments. Next, we use a generalized Hausman test to test the RE model against the FE model.[24] For all treatments the null hypothesis is rejected, i.e. the FE model is favored. Therefore we will mainly focus on the results of the FE model, but the OLS and RE estimates are interesting as well as they give an impression of the differences between the estimates of the three models.

Table 5 shows that adding supply variables to the demand variables increases the R^2 of the pooled OLS equation from 0.46 to 0.48. The three supply variables are significant at a 0.1 percent level, while the estimated coefficients of the demand variables remain relatively stable in the pooled OLS and the RE model. More variation in the estimated demand coefficients occur if we compare the RE model with the FE model.

This indicates that fixed effects are sometimes strongly correlated with demand variables. For example, the waiting time coefficient changes sign and has a positive significant effect, indicating that treatment densities are higher in those zip codes with longer waiting times. Also, urbanization changes to a significant positive coefficient indicating that people in high urbanized areas undergo less cataract treatments. This strong correlation with fixed effects

[23] Other results are available from the authors upon request.

[24] We performed this test with Stata, using the *xtoverid* command (see Schaffer and Stillman, 2010).

or other demand variables complicates the interpretation of the various effects. However, we are mainly interested in the effect of the supply variables. The estimated coefficients of physician density are relatively similar for all three models.

The estimated semi-elasticities $\hat{\xi}_\theta$ are presented in Table 7-A. We test hypothesis I using Wald tests. For all FFT physicians the semi-elasticies $\hat{\xi}_{FFT}$ are positive and significantly different from zero. For the GH physicians we find that $\hat{\xi}_{GH}$ is larger than zero for three treatments, for UH physicians this holds for four treatments (at a 0.1 percent significance level). Although we find for all cases that $\hat{\xi}_{FFT} > \hat{\xi}_{UH}, \hat{\xi}_{GH}$ the null hypothesis that $\hat{\xi}_{FFT} = \hat{\xi}_{UH}$ is not rejected for two treatments: varicose veins (dermatology) and hip fracture.[25] The null hypothesis $\hat{\xi}_{FFT} = \hat{\xi}_{GH}$ is not rejected in three cases: varicose veins (surgery), arthrosis (hip) and hip fracture.

These results confirm hypothesis I that FFT physicians are more vulnerable to SID than GH and UH physicians. For example a 1 percent increase in the number of ophthalmologists leads to an increase in the number of cataract treatments by 0.39 percent, if these 1 percent extra ophthalmologists are all paid FFT. This effect declines to 0.17 percent for UH ophthalmologists and 0.12 percent for GH ophthalmologists. The last row of Table 7-A shows that the average effect over all treatments equals 0.4 for FFT physicians and 0.15 for UH and GH physicians.

The Wald test rejects also the null hypothesis $\hat{\xi}_{GH} = \hat{\xi}_{UH}$ in five out of the nine cases. Out of these five times we find twice $\hat{\xi}_{GH} > \hat{\xi}_{UH}$ and three times $\hat{\xi}_{GH} < \hat{\xi}_{UH}$. Thus, we find no evidence that GH physicians are more or less sensitive to SID than UH physicians. [26]

Our findings suggest that demand inducement by FFT physicians could be an explanation for treatment differences. If there are relatively more FFT physicians working in a certain zip code area then, ceteris paribus, the number of treatments in that zip code area is higher. For GH physicians and UH physicians this effect is less clear-cut although we find weak positive effects for most of the treatments.

[25] If we consider the OLS and RE model we always find that $\hat{\xi}_{FFT} > \hat{\xi}_{UH}$ and $\hat{\xi}_{FFT} > \hat{\xi}_{GH}$, except for arthrosis (hip and knee). In all our tests we use a significance level of 5 percent.

[26] In section 6 we test both results in a slightly different way and confirm hypothesis I but we find that FW physicians are more susceptible to SID than UH physicians.

However, our results do not necessarily imply that FFT physicians supply too much health care. Patients may simply be undertreated. Although there is more anecdotal evidence available in the Netherlands that patients obtain too much than too little medical care, an extensive cost-benefit analysis would be necessary to assess this statement.

Our results are possibly driven by selection effects. For example, salaried physicians, especially those working in university hospitals, may have different medical ethics and practice styles than FFT physicians. We also believe that a comparison between FFT and GH - physicians is more reliable. These two types of physicians differ less in their productivity levels than UH physicians who spend more time on schooling/education and medical research. Our finding that GH and UH physicians are also in some cases susceptible to SID may reflect the preferences of the hospital management that provides incentives to salaried physicians to increase hospital turnover and profits.[27]

Our estimations broadly confirm hypothesis II too. We find weak support for demand inducement for varicose veins and hip fractures. Especially for varicose veins we find, in contrast to our *ex-ante* expectations, weak indications for SID. In university hospitals varicose veins are in more than 90 percent of the cases treated by dermatologists, whereas in general hospitals both dermatologists and surgeons perform about the same number of varicose veins treatments. This will lead to a bias in our results and it explains the relatively high semi-elasticity for UH physicians in the case of varicose veins (dermatology). For the other treatments with a high or medium *ex ante* chance of SID, we find strong positive effects for FFT physicians while the effect is (much) weaker for UH and GH physicians. We do not find large differences between treatments with a high or a medium *ex ante* chance of SID.

We confirm the *ex-ante* hypothesis for hip fractures in the case of GH and UH physicians. The positive effect for hip fractures for FFT physicians is difficult to interpret. It may be the case that we have to reject our *ex-ante* hypothesis, and that even for hip fractures some inducement may still be possible. However, it is more likely that the low number of observations for hip fractures is problematic. As a result, it is more difficult to control for demand side effects. Moreover, the allocation of physicians might become an issue when

[27] It may also reflect to some extent differences in practice styles or “keeping up with the Joneses”. Most physicians work in partnership and may not want to perform fewer treatments than their fellow physicians. Skinner (2011) reports examples of strong geographical variations in the UK, a health system with only salaried physicians.

the number of observations is low. We control for this possibility with robustness checks (section 6).

Our findings are in line with the first hypothesis that FFT physicians have a stronger incentive to induce demand. The second hypothesis is partly confirmed since we find weak indications for SID for hip fractures. For the treatments with a high or medium *ex ante* chance of SID, we find strong indications for its existence. An extensive cost-benefit analysis would assess the statement that patients in the Netherlands receive too much care.

5.2 Endogeneity of physician density

By including fixed effects and estimating SID along different dimensions we tackle the problem of correlation of physician density with omitted demand variables. Another way to cope with the problem of reverse causality is using instrumental variables. If the physicians' location is strongly endogenous, then the causal effect of physician density may not be consistently estimated. Earlier papers in this branch of the literature use a two-step estimator in which the first step is used to explain physician density, i.e. the location of physicians. For performing this first step one needs instruments that have enough power to explain physicians' location but are uncorrelated with the model's error terms (see e.g. Verbeek, 2010).

However, finding suitable instruments is a tough challenge. In the same spirit of previous papers we include house prices, number of cinema's, distance to public parks, and distance to university hospitals as instruments, and examined whether they are valid instruments. Our results are unreliable mainly due to the low explanatory power of our instruments in the first stage. Moreover, these instruments are correlated with the demand variables indicating weak identification problems.

A deeper investigation of the physicians' location yields that this differs across specialties. We find a weak correlation among physician densities of different treatments, indicating that location is difficult to explain. The average number of physicians per specialty in a Dutch hospital is between one and six, depending on the type of treatment. Thus, one additional physician in a hospital could substantially deliver more production. Until the year 2001 Dutch hospitals faced production restriction through budgets, releasing these budgets implied that hospitals could "in theory" increase their production to full capacity. In that case it may matter a lot whether one physician "more than average" works at a hospital.

Other explanations for the location of physicians could be opportunistic behavior of the hospital management or differences in practice styles among physicians in different areas. Also, more competition has led to an increasing number of private clinics. Physicians working in private clinics compete with a hospital to attract customers. In a competitive market with fixed demand the hospital should lower its production and reduce the number of physicians. However, if there is some degree of stickiness in mobility then physicians will not move to lower capacity regions or lower their productivity levels, with overproduction as a result. All these explanations make it very difficult to find good instrumental variables.

We test for physicians' geographical immobility suggesting that the current location of physicians is determined by past decisions, by using lagged physician densities as instrumental variables. The results of the two stage least squares estimations are presented in table 7-B. They broadly confirm our previous results.[28] Although lagged physician densities have enough explanatory power one caveat is that they are still likely to be correlated with the error terms.

Our search for good instruments faces the same difficulties as previous papers. The panel structure of our data allows us to use lagged physician density as an instrument. However, we rely on the random and fixed effects results for our main conclusions since we believe that the four-digit estimations better control for omitted variables. Besides, we exploit one extra wave of data.

6. Robustness tests

6.1 Alternative supply side variable

The outcomes of our model may depend on how we allocate physicians to zip code areas. In order to check our findings —and in particular the differences among physician types— we define the supply side variable in an alternative way. Instead of allocating the number of physicians to zip code areas we calculate the percentage of physicians of type θ visited by all patients in a two-digit zip code area. We distinguish between the three types of physicians in our original model and also include an unknown type (UN). The UN type represents those physicians working at private clinics and hospitals, for which we have no data. We denote

[28] One interesting result is that $\hat{\xi}_{GH} > \hat{\xi}_{UH}$ in seven out of the nine cases (see section 6.1).

the percentage of physicians of type θ visited by patients in a two-digit zip code area i in year t with $p_{\theta,it}$. The descriptive statistics are presented in Table 4-D. On average 75 percent of the patients visit a FFT physician. For varicose veins the type of the physician is unknown in about 30 percent of the cases. This indicates that varicose veins are relatively often treated in private clinics where no physician data is available.

We include the newly specified supply side variable in our model and estimate equation [2] ($p_{UH,it}$ is left out since its inclusion would lead to perfect multicollinearity) [29]:

$$y_{it} = \alpha_i + \gamma_t + \delta_{GH} p_{GH,it} + \delta_{FFT} p_{FFT,it} + \delta_{UN} p_{UN,it} + Z'_{it}\beta + \varepsilon_{it} \qquad [2]$$

In case of no SID we expect that $\delta_\theta = 0$; i.e. the type of physician visited by patients should not be related to the treatment density. However, when SID occurs we expect to find $\delta_{FFT} > 0$, and $\delta_{FFT} > \delta_{UH}$, δ_{GH}. First of all it is interesting to look at the individual coefficients δ_θ for the nine different treatments[30]. In general we find positive and significant coefficients for GH, FFT, and UN physicians indicating that the number of treatments is higher when relatively more patients visit a physician of one of these types (note that UH physicians form the base group). In contradiction to our previous findings we do not find any effect for hip fractures. Even for FFT physicians the effect is close to zero and insignificant. This confirms our *ex ante* expectation that SID does not play a role for hip fractures.

After estimation we calculate the effect on treatment density of a 1 percent increase in the percentage of θ type physicians visited and a simultaneous 1 percent decrease in the percentage visited of another type of physicians. The results are presented in Table 8-A.

INCLUDE TABLE 8-A AND 8-B AROUND HERE

The results broadly confirm our previous findings. For all treatments we find that $\hat{\delta}_{FFT} > \hat{\delta}_{UH}$. Also, for all treatments, but varicose veins (surgery), we find that $\hat{\delta}_{FFT} > \hat{\delta}_{GH}$,

[29] Since $\sum_\theta p_{\theta,it}$=1. Note that in our calculations for $p_{\theta,it}$ we use less information than for $x_{\theta,it}$. The drawback is that we cannot calculate semi-elasticities $\hat{\xi}_\theta$. We can only measure relative effects.

[30] The complete regression results are available upon request from the authors.

i.e. the treatment density is on average higher when patients visit more FFT physicians than the other two types of physicians. This confirms our hypothesis I.

The result differences for FFT and UH physicians are larger compared to the previous estimations. For all treatments we find that: $\hat{\delta}_{FFT} - \hat{\delta}_{UH} > \hat{\xi}_{FFT} - \hat{\xi}_{GH}$. An explanation could be that there are relatively few UH physicians and there is little within variation in the UH percentages (see Table 4-D), which makes it difficult to estimate $\hat{\delta}_{UH}$ very precisely.

When we compare FFT physicians and UN physicians, we do not find significant differences in most cases. Only for varicose veins (dermatology) and, to a lesser extent, tonsillectomy we find that $\hat{\delta}_{FFT} < \hat{\delta}_{UN}$, i.e. SID is significantly stronger for UN physicians than FFT physicians. This result is in line with our findings because most UN physicians are working in private clinics and are paid FFT. For varicose veins (dermatology) and tonsillectomy physicians working in private clinics are actually even more prone to SID than FFT physicians working in general hospitals.

6.2 Constant zip code shares

The within variation of the physician density originates from two sources. First, the share of the two-digit zip code in a hospital's production varies over the years. Second, the number of physicians working in a hospital changes over the years[31]. We check our previous results by keeping the zip code shares in the production of the hospitals constant, i.e. we calculate the average zip code shares for the period 2006-2009. By doing so we measure the impact of changes in the number of physicians working in the hospitals visited by patients from a two-digit area. The results are highly comparable to the results in Table 7-A[32].

6.3 Patients crossing international country borders

Several patients in the Netherlands cross country borders to receive a medical treatment in Germany or Belgium. Unfortunately there is no information available on patient mobility for the researched treatments in this paper. Cross-border health care costs are currently about 0.3-0.4 percent of total health care costs (see www.cvz.nl). An issue that may arise in

[31] This assumes that the population size of two-digit zip code areas remains relatively constant over time, which is a reasonable assumption if we look at our data.

[32] The complete regression results are available upon request from the authors.

our study is that the observed patient densities in areas adjacent to the country borders will be lower than predicted by the demand variables. Since we fail to correct properly for demand in that case, our results could be biased. Moreover, the allocation of physicians to zip code areas is based on the number of treatments. This implies that we allocate a relatively low number of physicians to border areas if country border crossing takes place, potentially leading to artificial correlation between treatment and physician densities. For these reasons we exclude all 26 two-digit zip code areas close to the Belgian and German border (which reduces the number of zip code areas included in our regressions by about 30 percent) and re-estimate our models. The results are presented in table 9 and are broadly comparable with the results in table 7-A.

6.4 Treatment density at a three digit zip code

The number of patients in a four-digit zip code area can be low or zero for some treatments. In that case one patient more or less may cause a substantial change in the patient density. Therefore, as a robustness test, we perform the same analysis at three digit zip code level. The annual number of zip code areas is now reduced from 2,750 (four-digit zip code level) to about 700 (three digit zip code level) and the average population size increases from 5,000 (four-digit zip code level) to slightly more than 20,000.

The estimation results on the three digit zip codes are presented in Table 9. The results confirm the analysis with patient densities on the four-digit zip code level.

INCLUDE TABLE 9 ABOUT HERE

6.5 Other demand and supply aspects

In the literature of regional variation both excess demand and availability effects are often mentioned as possible reasons for finding SID, that is actually not present (Zweifel et al., 2009). Also, treatment variation across geographical areas may be found due to regional specialization instead of SID (Chandra and Staiger, 2007).

We include in our analysis waiting time data and data on the availability of hospitals and GPs. We find that waiting time data and availability effects are important for explaining treatment density —the effects are significant in almost all regressions— but we do not find that they strongly influence our SID-hypotheses —the estimated semi-elasticities $\hat{\xi}_\theta$ do almost not alter if we remove waiting time and availability effects from our set of regressors. The reason is that we do not find strong correlation between physician density and waiting time or availability factors in our data.

Chandra and Staiger (2007) study treatments of heart attacks and provide evidence that geographical variation in treating heart attacks can better be explained by regional specialization than SID. For our treatments regional specialization and technological innovations do not seem to be an important issue. First of all, technological innovations play a smaller role for the treatments we consider. Second, a specialization effect will be smaller in the Netherlands since the country is relatively small, thus most (specialized) hospitals can be reached by patients within two hours travelling time. Third, we partly control for quality and specialization effects of hospitals by using zip code specific effects. Fourth, university hospitals are technologically the most advanced hospitals and thus should attract more patients. On the contrary, we show that less patients are treated in zip code areas with relatively many UH physicians. It may even be the case that UH physicians are less interested in performing relatively 'easy' treatments such as tonsillectomies and varicose veins.

7. Discussion and conclusions

The Dutch government liberalized in 2001 the provision of hospital services by payment systems that were to a large extent volume based and open-ended, in which "money follows the patients". In 2005 this policy was accompanied by the introduction of a new hospital payment system called DTC (Diagnosis Treatment Combination). In combination with patients facing limited cost-sharing and free hospital choice this led to a strong growth in hospital production. The question whether this strong growth favored patients or not — and whether or not the Dutch system suffers from the 'flat of the curve' medicine— can only be answered by an extensive cost-benefit analysis. However, it is clear that the Dutch reform gave incentives to physicians and hospitals to induce patient demand.

We find strong indications for the existence of SID. However, it is important to note that our results cannot be generalized to the entire Dutch hospital sector. Moreover, an extensive cost-benefit analysis is needed to determine if our findings point to overproduction or to the provision of 'unnecessary care'. Although the well-known parable of Victor Fuchs (1986) "Always that doubt, always that doubt" still holds for our analyses, we believe that we made an important step forward.

To estimate the effect of supply side factors on regional variation for nine different hospital treatments, we exploit the variation in physician density and the differences in fee structures among physicians. For physicians with a FFT payment we find strong indications for demand inducement. Our results indicate that a 1 percent increase in the number of physicians increases the total number of treatments on average by 0.4 percent if these extra physicians are all paid FFT. For salaried physicians working in university hospitals and general hospitals we find on average a significantly lower effect of 0.15 percent. Our findings imply that the number of treatments is higher in areas where patients visit relatively more FFT physicians compared to areas where patients visit more salaried physicians. If we substitute in an average zip code area 1 percent FFT physicians for salaried physicians then the number of treatments decreases on average by 0.25 percent. Within the category salaried physicians we distinguish between physicians working in university hospitals and general hospitals. Our research does not indicate strong significant differences between these types of physicians. We also find that the strength of the effect is related to the *ex ante* chance of SID. For hip fractures, the only treatment we include with a low chance of SID, we find no or very weak effects. For the other treatments we find much stronger indications of SID.

Our results are in line with earlier papers on SID such as Fuchs (1978) and Cromwell and Mitchell (1986) who report strong SID indications in the US. The main contribution of our research is that we use a comprehensive dataset over four years that allows us to control for most of the pitfalls reported in the literature (e.g. Dranove and Wehner, 1994; Zweifel et al., 2009). Although we have all administrative data of Dutch hospitals and most private clinics we acknowledge that about 8 percent of the delivered data has wrong or non-existing zip code information. In regional variation analysis with small areas it is important that enough treatments occur in each zip code area (see e.g. Diehr et al., 1992), therefore we believe that our results are more reliable for treatments that occur more frequently such as cataracts and tonsillectomies. Another crucial point in our analysis is the choice of the combination type of treatment and specialty. For our analysis it would be ideal if one type of physician performs only one type of treatment in all hospitals. In practice, however, our analysis is complicated by physicians performing different types of treatments. This holds especially for physicians working in university hospitals and for treatments with a very low frequency.

The finding that supply side factors are related to regional variation has important policy implications for supply and demand side regulation. Several policy measures are possible.

First, if there is a general notion by the hospital management that physicians overproduce then regressive tariffs can be introduced to soften SID. Second, differences in practice variation or 'schools of thoughts' within hospitals should be investigated and acknowledged. Managed care activities or benchmarking by insurers could reveal such regional variation. Third, SID can be pushed back by increasing cost sharing arrangements with consumers for treatments that are most vulnerable to it. Fourth, SID can affect the entry regulation of physicians into the market. The abolishment of FFT types of payment might lead to a decrease in average physician productivity, which implies that more physicians are needed to treat a given number of patients.

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Appendix A. DTC Codes

All nine treatments are evaluated by Dutch medical experts on two criteria:

1) Unambiguous treatment plan: this means that there is a clear-cut way in the medical literature to treat patients for the corresponding diagnosis.

2) Medical risks: this measures how risky the treatment is, i.e. whether we can expect a substantial health damage given the diagnosis. Substantial health damage is defined as: risk of death, life-threatening situations, hospital intake, and long-term invalidity.

Based on the scores of these two criteria the medical experts indicated whether there is a significant chance of SID in treating the specified diagnosis. We summarize this information in Table A1.

Cataract for example is an unambiguous treatment plan. In other words there are well-defined cataract surgeries in the medical literature. Medical risks are low, i.e. no substantial risks of death, or of incurring into life-threatening situations, or of needing a hospital intake, or developing a long-term invalidity. This leads to the statement that the ex-ante indication of SID is strong, i.e. we expect SID for cataract surgery.

A description of the DTC codes is presented in Table A2.

Table A1. Evaluations of treatments by medical experts

Treatment	**Specialty**	**Unambiguous treatment plan**	**Medical risks**	**Ex-ante indication of SID**
Cataract	Ophthalmology	Yes	Low	Strong
Tonsillectomy	Otolaryngology	No	Medium	Strong
Hernia	Neurology	Yes	Medium	Average
Varicose veins	Dermatology	No	Low	Strong
Varicose veins	Surgery	No	Low	Strong
Inguinal hernia	Surgery	Yes	Low	Average/Strong
Arthrosis (knee)	Orthopedics	No	Medium	Average
Arthrosis (hip)	Orthopedics	No	Medium	Average
Hip fracture[+]	Surgery	Yes	Medium	Weak

Table A2. Description of DTC-codes

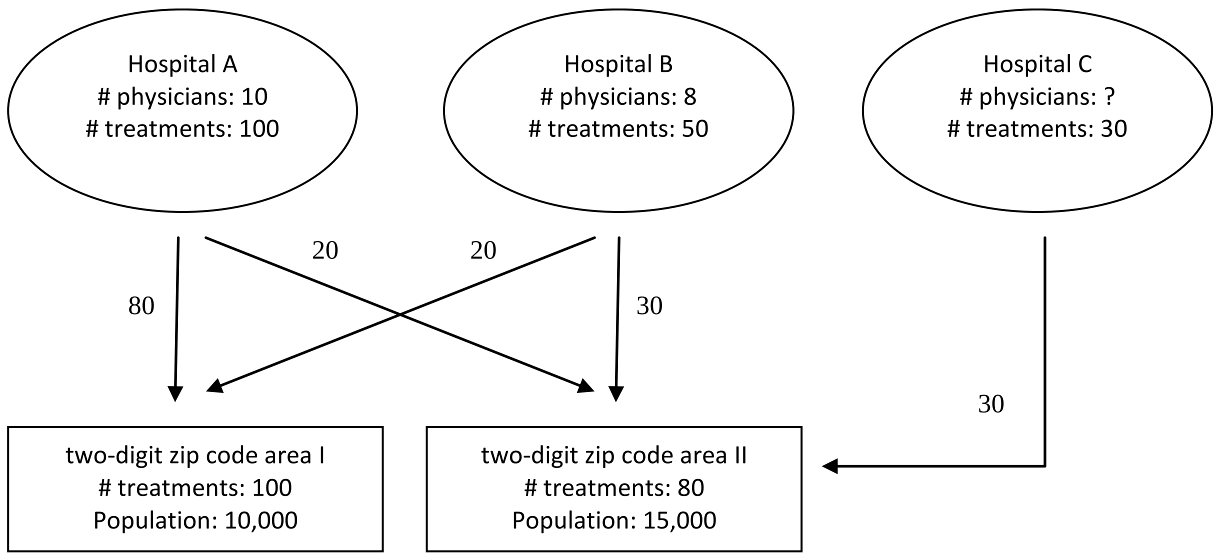
TREATMENT	SPECIALTY & SPECIALTY CODE	DTC CODES	DESCRIPTION
Cataract	Ophthalmology; 301	X1000554003Y X=1, 2 Y=1, 2, 3, 6	Cataract treatments can essentially be divided into three categories: - Day treatment; - Inpatient treatment; - Outpatient treatment.
Tonsillectomy	Otolaryngology; 302	X1000052021Y X=1, 2 Y=1, 2, 3, 6	Tonsillectomy can essentially be divided into three categories: - Day treatment; - Inpatient treatment; - Outpatient treatment.
Hernia	Neurology; 330	X100120301YZ X=1, 2 Y=1, 2, 3 Z=1, 2, 3	Treatment for hernia within neurology is conservative, i.e. it avoids radical medical therapeutic measures or operative procedures.
Varicose veins	Dermatology; 310	X100002400YZ X=1, 2 Y=3, 4, 5, 8, 9 Z=1, 2, 3	Treatment for varicose veins can be: laser treatment to destroy the vein, sclerotherapy to close off the vein, and surgery to tie off or remove the vein. These treatments can be further classified in day treatment vs. inpatient/outpatient treatments. These latter are used for the most invasive operations.
Varicose veins	Surgery; 303	110004230X0Y X=2, 4 Y=1, 2, 3, 6	Treatment for varicose veins can be: laser treatment to destroy the vein, sclerotherapy to close off the vein, and surgery to tie off or remove the vein. These treatments can be further classified in day treatment vs. inpatient/outpatient treatments. These latter are used for the most invasive operations.
Inguinal hernia	Surgery; 303	110001210X0Y X=2, 3, 4, 5 Y=1, 2, 3	Inguinal hernia can be treated with an endoscopic/minimal invasive surgery - usually for relatively easier cases - or with open/classic surgery, which is more invasive.
Arthrosis (knee)	Orthopedics; 305	X100180102YZ X=1, 2 Y=1, 2 Z=1, 2, 3, 6	Arthrosis of the knee can be treated with or without intervention/operation. Also, the operation can include prosthesis or not.
Arthrosis (hip)	Orthopedics; 305	X100170102YZ X=1, 2 Y=1, 2 Z=1, 2, 3, 6	Arthrosis of the hip can be treated with or without intervention/operation. Also, the operation can include prosthesis or not.
Hip fracture	Surgery; 303	110002180X03 X=2, 4	Most hip fractures are treated by orthopedic surgery, which involves implanting an orthosis. If operative treatment is refused or the risks of surgery are considered to be too high the main emphasis of treatment is on pain relief.

Appendix B. The construction of treatment and physician density

In contrast to Fuchs (1978) and other studies that use survey information, we have administrative data for nine treatments. These data includes precise information about the home address of the patient and the address of the hospital, which allows us to take border crossing of patients into account. We start with a simple example in order to explain the method we use to allocate physicians from hospitals to two-digit zip code areas.

Suppose there are two two-digit zip code areas (I and II) and two hospitals (A and B) for which we know the number of physicians and a third hospital (C) for which no information is available on the number of physicians. This situation is illustrated in figure B1, where the arrows indicate how the patients treated in each service area are divided over the hospitals. In this example the allocation of physicians to area I is straightforward. Area I accounts for 80 percent of the production of hospital A. Therefore we allocate eight (80 percent of ten) physicians from hospital A to area I. Similarly we allocate 3.2 physicians from hospital B to area I, yielding a total number of 11.2 physicians in area I. The physician density is found by dividing 11.2 by the population size of area I.

Figure B1: allocation of physicians to zip code areas



Although this procedure is rather simple there is a pitfall. This procedure works only if the number of treatments in a zip code area is large enough. Ideally we would like to allocate physicians to the four-digit zip code level. However, for many treatments we have only a few observations at a four-digit zip codes which could artificially create correlation between treatment density and physician density. Moreover, the variation of treatment density could be substantial which implies that patients living in adjacent four-digit zip code areas would face strongly different choice possibilities. To obtain enough treatments per "service area" we decided to allocate physicians on the two-digit zip code level, which restricts the number of service areas to 90. Our definition of service areas differ from the traditional hospital service area (see e.g. Wennberg, 2010) in the sense that the borders are chosen on administrative basis. This is not a problem in our model because we correct for cross-border mobility across service areas.

An attractive feature of our dataset is that we can correct for missing data. We illustrate this by calculating the physician density in area II. In our calculations we have to take into account that we have no data on the number of physicians working in hospital C. Therefore we first adjust the population size in service area II. In area II, 80 patients receive a treatment, but only for 50 patients we have information about the corresponding number of physicians. In order to correct for this we scale down the population size by a factor of 50/80. Otherwise we would underestimate the real physician density in area II. Next, we allocate physicians to area II in the same way as explained above.

Note that we calculate the physician density for each type of physician (FFT, GH, and UH) and for each treatment (also within a specialty) separately. This allows us to indentify different demand inducement effects for each type of physician and to take into account that these physicians have different workloads (see Table 4-A). Note that physicians do not devote all their time to the treatments that we have included in our analysis. We implicitly assume that the average physician across all hospitals devotes the same share of his time on the treatments we investigate. Our estimation results could be biased if physicians in some hospitals are more specialized in certain treatments than in others. In that case we may allocate too many (or too few, depending on the type of specialization) physicians to certain zip code areas.

The formal computations look as follows: we denote the number of patients living in four-digit zip code area $i = 1, \ldots, I$, treated in hospital $h = 1, \ldots, H$ in year $t = 2006, \ldots, 2009$ by $T_{4,iht} \in \mathbb{R}_{+}$. The same number, but then for two-digit zip code area $j = 1, \ldots, J$ is denoted by $T_{2,jht}$. We distinguish between three types θ of physicians, with $\theta \in \{\mathrm{GH}, \mathrm{UH}, \mathrm{FFT}\}$. The number of physicians working in hospital h is denoted by $P_{\theta ht}$ (fulltime equivalents). Finally, $N_{4,it}$ represents the total population of four-digit zip code area i and $N_{2,jt}$ stands for the population size of two-digit zip code area j.

The dependent variable in our model is the treatment density in a four-digit zip code area i is and is denoted by y_{it}:

$$y_{it} = \frac{\sum_{h=1}^{H} T_{4,iht}}{N_{4,it}} \qquad \text{(B1)}$$

Before starting with the allocation of physicians to zip code areas we need to take into account that for about 8 percent of the observations the hospitals entered a non-existing patient zip code. Ignoring this aspect would allocate physicians who treated patients with a non-existing zip code to areas with an existing zip code. Therefore, we have to correct the number of physicians:

$$\tilde{P}_{\theta ht} = P_{\theta ht}\left(\frac{\sum_{i=1}^{I} a_i T_{4,iht}}{\sum_{i=1}^{I} T_{4,iht}}\right) \qquad \text{(B2)}$$

where $a_i = 1$ if zip code i exists and 0 otherwise. Next we allocate physicians to two-digit zip code areas. The number of physicians allocated to two-digit zip code area j, in year t is given by:

$$P_{\theta jt} = \sum_{h=1}^{H}\left(\frac{T_{2,jht}}{\sum_{i=1}^{J} T_{2,iht}}\tilde{P}_{\theta ht}\right) \qquad \text{(B3)}$$

Next, we correct the population size for the possibility that patients visited hospitals for which no physician data was available. Therefore we count the number of patients in two-digit zip code area j who visited hospitals for which we have information about the number of physicians and divide it by the total number of patients in area j in year t. We multiply this ratio with the actual population size to obtain the corrected population:

$$\tilde{N}_{2,jt} = N_{2,jt}\left(\frac{\sum_{h=1}^{H} b_h T_{2,jht}}{\sum_{h=1}^{H} T_{2,jht}}\right) \qquad \text{(B4)}$$

where $b_h = 1$, if we observe the number of physicians in hospital $h = 1$, and zero otherwise. The physician density is now determined by: $x_{\theta it} = \frac{P_{\theta jt}}{\tilde{N}_{2,jt}}$. Note that this density is defined on the four-digit zip code level, but the density is the same for every four-digit zip code area i within a certain two-digit zip code area j.

Appendix C. Estimation of the demand equation

We follow the literature on small area variation and study the variation of hospital treatments in four-digit zip code areas after we control for demand variables. We estimate for each of the nine treatments a simple demand equation of the following form:

$$y_{it} = \alpha + \gamma_t + Z_{it}^{'}\beta + \varepsilon_{it} \quad \text{(C1)}$$

where y_{it} represents the treatment density for zip code area $i = 1, \dots, I$ in year t, Z_{it} represents the vector of demand variables, and γ_t are year dummies to control for year specific effects.

We estimate equation (1) with pooled OLS weighing all zip code areas equally. Our main interest concerns the error terms ε_{it}. When SID occurs we expect the error terms ε_{it} not to be randomly distributed. Since people and physicians do not tend to move we expect positive correlation over time. Moreover, because most people visit a hospital close to their residence we expect positive spatial correlation. Therefore we test whether the error terms ε_{it} exhibit positive autocorrelation and positive spatial correlation[33]. These tests do not prove the existence of SID, since the correlation can also be the result of omitted demand variables or other differences in supply such as the differences in physician practice, but give a first indication of SID.[34] First, we test for autocorrelation by computing:

$$\varepsilon_{it} = \alpha + \rho_{AC}\varepsilon_{i,t-1} + \eta_{it} \quad \text{(C2)}$$

(in which α is a constant and η_{it} is an error term). Second, we perform a test for spatial correlation by relating for every year the error terms ε_{it} to the unweighted average of the error terms in the five nearest zip code areas ε_{wit}:

$$\varepsilon_{it} = \alpha + \rho_{SC}\varepsilon_{wit} + \nu_{it} \quad \text{(C3)}$$

(in which α is a constant and ν_{it} is an error term). This leads to the following two hypotheses:

HYPOTHESIS III A necessary, but not sufficient, condition for the occurrence of SID is that the estimated coefficient for autocorrelation, $\hat{\rho}_{AC} > 0$.

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[33] Diehr et al. (1992) provide another test. Advantages of both our tests are that no additional assumptions about the distribution of the error terms are required.

[34] SID could also exist if we find zero correlation. In that case supply variables, such as physician density, are perfectly correlated with demand variables and we cannot distinguish between demand and supply. Note, that we did not include random and fixed effects in our model because they could be correlated with supply variables as well.

HYPOTHESIS IV. A necessary, but not sufficient, condition for the occurrence of SID is that the estimated coefficient for spatial correlation, $\hat{\rho}_{SC} > 0$.

We estimate equation (C1) for all nine treatments.[35] The results of our two hypotheses I and II are presented in Table 6. Remarkably, results for $\hat{\rho}_{AC}$ and $\hat{\rho}_{SC}$ are all positive and significant at a 0.1 percent level. Treatments with relatively low autocorrelation and spatial correlation coefficients are hip arthrosis and inguinal hernia. For hip fractures we find relatively low coefficients for spatial correlation, although higher ones for autocorrelation which may indicate that we have completely controlled for demand side characteristics.

In the last three columns of table 6 we provide information about the average patient density ($\bar{y}$), mean average error terms (MAE) and the coefficient of variation ($\hat{\sigma}_{\varepsilon}/\bar{y}$) to get an impression of the size of the error terms. Both, the MAE and the coefficient of variation indicate that that there is considerable variation across zip code areas. In combination with the strong positive correlations we cannot reject SID for all treatments.

INCLUDE TABLE 6 AROUND HERE

[35] The complete estimation results are available from the authors upon request.

Table 1-A. Number of treatments, patient and hospital characteristics, and supply-sensitiveness of treatments

Treatment	Specialty	Number of Treatments				Average age	Percentage men	Number of hospitals and clinics**	Ex-ante chance supply sensitiveness
		2006	*2007*	*2008*	*2009**				
Cataract	Ophthalmology	134,107	144,874	160,231	145,339	70	39	117	High
Tonsillectomy	Otolaryngology	61,707	62,000	57,007	53,178	10	50	103	High
Hernia	Neurology	49,682	49,180	53,130	52,001	49	51	107	Medium
Varicose veins	Dermatology	37,366	45,526	53,510	56,051	49	15	139	High
Varicose veins	Surgery	26,551	30,721	34,491	33,912	49	25	123	High
Inguinal hernia	Surgery	29,105	30,983	30,415	27,555	48	89	109	Medium
Arthrosis (knee)	Orthopedics	30,561	32,721	34,272	31,016	60	39	111	Medium
Arthrosis (hip)	Orthopedics	21,765	22,155	23,222	21,099	66	32	104	Medium
Hip fracture	Surgery	9,428	9,648	10,141	9,493	76	30	96	Low

* Note that in 2009 the reported number of patients is somewhat lower than in previous years. One explanation is that the dataset for the year 2009 is still incomplete. After closing a DTC providers must send this information to the *DTC-informatiesysteem DIS*. There is no legal instrument to commit providers to deliver DTC's within a specified time period. This causes some time lags in getting the data.

** There are 8 university hospitals. The number of general hospitals decreased from 88 in 2006 to 85 in 2009. Hospitals are obliged to report their DTC data to the NZa but this requirement does not hold for private clinics. In our dataset we have 44 (2006), 57 (2007), 74 (2008) and 78 (2009) unique private clinics while the NZa (2010) reports 57 (2006), 68 (2007), 89 (2008) and 129 (2009) private clinics in the B part. It is not entirely clear how much data we may miss since the NZa (2010) counts also private clinics that perform exclusively treatments we do not consider.

Table 1-B. Descriptive statistics of treatment density*

Treatment	Specialty	Average treatment density			
		2006	*2007*	*2008*	*2009*
Cataract	Ophthalmology	7.6 (4.4)	8.5 (4.6)	9.5 (5.2)	8.7 (4.8)
Tonsillectomy	Otolaryngology	3.7 (2.1)	3.7 (2.0)	3.3 (1.9)	3.1 (1.9)
Hernia	Neurology	2.8 (1.6)	2.9 (1.6)	3.1 (1.8)	3.1 (2.0)
Varicose veins	Dermatology	2.2 (2.2)	2.7 (2.3)	3.3 (2.8)	3.4 (2.8)
Varicose veins	Surgery	1.6 (1.1)	1.9 (1.3)	2.1 (1.5)	2.1 (1.5)
Inguinal hernia	Surgery	1.8 (1.0)	2.0 (1.1)	1.9 (1.1)	1.7 (1.1)
Arthrosis (knee)	Orthopedics	1.8 (1.3)	2.0 (1.3)	2.1 (1.5)	2.0 (1.3)
Arthrosis (hip)	Orthopedics	1.3 (1.0)	1.4 (1.0)	1.4 (1.1)	1.3 (1.0)
Hip fracture	Surgery	0.6 (0.9)	0.6 (0.8)	0.6 (1.0)	0.5 (0.9)

* The figures are the average treatment densities per 1000 inhabitants of the included four-digit zip code areas in our regressions. The standard deviations are reported between brackets.

Table 2. Descriptive statistics of 4-digit zip code areas

	2006	2007	2008	2009
Total number zip codes	4,007	4,014	4,015	4,019
Number of zip codes included in regressions	2,603	2,640	2,864	2,929
Average population	5,101	5,222	5,020	5,094
Demand variables (standard deviation)				
age0_5 (%)	6.1 (1.7)	5.9 (1.7)	5.7 (1.7)	5.5 (1.6)
age5_10	6.3 (1.6)	6.3 (1.6)	6.4 (1.6)	6.3 (1.6)
age10_15	6.3 (1.5)	6.3 (1.5)	6.2 (1.5)	6.2 (1.5)
age15_20	6.1 (1.3)	6.2 (1.4)	6.2 (1.3)	6.2 (1.3)
age20_25	5.5 (2.7)	5.5 (2.9)	5.5 (2.9)	5.6 (2.9)
age25_30	5.5 (2.6)	5.4 (2.6)	5.4 (2.6)	5.4 (2.6)
age30_35	6.5 (2.0)	6.1 (2.0)	5.8 (2.0)	5.6 (2.0)
age35_40	7.9 (1.6)	7.8 (1.6)	7.6 (1.6)	7.3 (1.6)
age40_45	8.1 (1.3)	8.1 (1.3)	8.0 (1.3)	8.0 (1.3)
age45_50	7.6 (1.3)	7.7 (1.3)	7.8 (1.3)	7.9 (1.3)
age50_55	7.1 (1.4)	7.1 (1.4)	7.2 (1.4)	7.3 (1.4)
age55_60	7.3 (1.7)	7.1 (1.6)	6.9 (1.5)	6.9 (1.5)
age60_65	5.4 (1.5)	5.9 (1.6)	6.4 (1.7)	6.6 (1.7)
age65_70	4.4 (1.4)	4.5 (1.4)	4.6 (1.4)	4.7 (1.4)
age70_75	3.6 (1.3)	3.6 (1.3)	3.7 (1.3)	3.8 (1.3)
age75_80	2.8 (1.3)	2.9 (1.3)	2.9 (1.3)	3.0 (1.3)
age80_85	2.0 (1.2)	2.0 (1.2)	2.0 (1.2)	2.0 (1.2)
age85_90	1.0 (0.9)	1.0 (0.9)	1.1 (0.9)	1.2 (0.9)
age90_95	0.4 (0.4)	0.4 (0.4)	0.4 (0.4)	0.4 (0.4)
age95	0.1 (0.1)	0.1 (0.1)	0.1 (0.2)	0.1 (0.2)
men (%)	49.9 (1.8)	49.9 (1.8)	49.9 (1.8)	49.9 (1.8)
mortality (per 1,000)	7.5 (5.8)	7.4 (5.8)	7.5 (5.6)	n/a
westerns (%)	7.7 (4.9)	7.8 (4.9)	7.8 (4.9)	7.9 (4.9)
nonwesterns (%)	7.1 (10.6)	7.1 (10.7)	7.2 (10.8)	7.4 (10.9)
urbanized	3.7 (1.4)	3.6 (1.4)	3.6 (1.4)	3.6 (1.4)
social assistance (per 1,000)	35.4 (37.5)	32.3 (34.8)	29.7 (32.7)	28.9 (31.2)
lowincome (%)	40.5 (5.9)	40.3 (5.8)	n/a	40.2 (6.6)
highincome (%)	20.5 (7.5)	20.7 (7.5)	n/a	19.9 (7.8)
working (% of population 15-65)	71.3 (6.1)	73.4 (5.9)	74.3 (5.8)	n/a
selfemployed (% of working people)	9.2 (4.5)	9.4 (4.5)	9.5 (4.4)	n/a
distGP (km)	n/a	1.3 (1.2)	1.4 (1.2)	n/a
av3GP (number of GP's within 3 km)	n/a	7.0 (9.9)	6.8 (9.8)	n/a
distGPcentre (km)	n/a	7.3 (5.1)	7.3 (5.1)	n/a
av20hospital (number of hospitals within 20 km)	n/a	4.3 (4.1)	4.4 (4.2)	n/a

Table 3. Average waiting times of two-digit zip code areas

Treatment	Specialty	Average waiting time in weeks			
		2006	*2007*	*2008*	*2009*
Cataract	Ophthalmology	6.6 (2.2)	6.4 (2.4)	6.1 (2.0)	4.9 (2.3)
Tonsillectomy	Otolaryngology	5.0 (1.4)	4.7 (1.3)	4.2 (1.2)	3.9 (1.3)
Hernia	Neurology	n/a	n/a	n/a	n/a
Varicose veins	Dermatology	n/a	n/a	n/a	n/a
Varicose veins	Surgery	6.8 (2.2)	6.2 (2.3)	5.6 (2.4)	4.4 (2.1)
Inguinal hernia	Surgery	4.6 (1.0)	4.3 (1.2)	4.6 (1.3)	4.3 (1.4)
Arthrosis (knee)	Orthopedics	9.8 (3.6)	8.3 (2.6)	7.8 (1.9)	6.7 (2.2)
Arthrosis (hip)	Orthopedics	8.3 (2.6)	7.7 (2.0)	7.3 (1.8)	6.8 (2.2)
Hip fracture	Surgery	n/a	n/a	n/a	n/a

* For Varicose veins (neuroloy and dermatology) and surgery we did not include waiting lists in our estimations. In robustness section 6 we discuss the importance of waiting list data. The standard deviations are reported between brackets.

Table 4-A. Descriptive statistics total number of physicians and average annual productivity*

Treatment	Specialty	Total number of physicians (FTE)												Average productivity		
		2006			*2007*			*2008*			*2009*			*2006-2009*		
		UH	GH	FFT	UH	GH	FFT	UH	GH	FFT	UH	GH	FFT	UH	GH	FFT
Cataract	Ophthalmology	n/a	38	296	65	28	293	68	28	286	76	36	290	86	330	371
Tonsillectomy	Otolaryngology	n/a	29	248	67	24	239	67	29	235	71	21	254	25	127	190
Hernia	Neurology	n/a	98	295	121	90	289	120	100	279	123	84	325	8	79	121
Varicose veins	Dermatology	n/a	31	180	52	28	186	53	22	184	45	18	196	47	97	135
Varicose veins	Surgery	n/a	71	554	250	56	546	249	58	551	238	45	587	1	35	34
Inguinal hernia	Surgery	n/a	71	554	250	56	546	249	58	551	238	45	587	7	33	41
Arthrosis (knee)	Orthopedics	n/a	54	307	54	48	308	59	41	309	57	41	334	22	57	74
Arthrosis (hip)	Orthopedics	n/a	54	307	54	48	308	59	41	306	57	41	334	13	34	55
Hip fracture	Surgery	n/a	71	548	250	56	535	249	58	528	238	45	576	3	20	24
	Number of hospitals		83			87			84			88				

* For the year 2006 we used the number of UH physicians of 2007. Note that especially for UH physicians the annual productivity can be low. For example for varicose veins (surgery) there are about 250 UH physicians in our sample that on average treat about one patient a year. Broadly speaking, one could state that the higher the productivity levels the more time physicians devote to the particular treatment and therefore the more reliable is the construction of the physician density variable. Note also that in some hospitals both FFT and GH physicians are working. In 2006 there were 16 hospitals were both FFT and GH physicians worked. This increased to 17 hospitals in 2007, 18 hospitals in 2008 and 20 hospitals in 2009.

Table 4-B. Descriptive statistics physician density (for two-digit zip code areas)*

Treatment	Specialty	Average physician density (physicians per 100,000)												Average standard deviation		
		2006			*2007*			*2008*			*2009*			*2006-2009*		
		UH	GH	FFT	UH	GH	FFT	UH	GH	FFT	UH	GH	FFT	UH	GH	FFT
Cataract	Ophthalmology	0.54	0.18	2.04	0.63	0.11	2.13	0.64	0.14	2.07	0.72	0.20	2.10	0.96	0.43	0.72
Tonsillectomy	Otolaryngology	0.50	0.13	1.63	0.58	0.12	1.66	0.54	0.17	1.63	0.53	0.09	1.70	0.80	0.39	0.53
Hernia	Neurology	0.91	0.61	1.97	1.02	0.60	2.06	0.98	0.86	1.95	0.96	0.70	2.24	1.35	1.09	1.08
Varicose veins	Dermatology	0.53	0.22	1.56	0.66	0.32	1.75	0.67	0.34	1.73	0.64	0.23	2.09	1.16	0.84	1.16
Varicose veins	Surgery	2.31	0.41	4.68	3.11	0.46	5.10	3.16	0.61	5.31	3.11	0.43	6.12	5.36	1.30	3.04
Inguinal hernia	Surgery	1.91	0.35	3.63	2.01	0.34	3.76	2.06	0.37	3.76	1.80	0.25	3.98	2.17	0.83	1.21
Arthrosis (knee)	Orthopedics	0.42	0.21	2.14	0.50	0.20	2.30	0.53	0.20	2.31	0.45	0.14	2.53	0.67	0.45	0.82
Arthrosis (hip)	Orthopedics	0.42	0.20	2.05	0.53	0.18	2.21	0.50	0.18	2.19	0.44	0.12	2.37	0.72	0.41	0.77
Hip fracture	Surgery	1.60	0.32	3.39	1.71	0.30	3.50	1.58	0.35	3.38	1.51	0.24	3.59	2.82	0.77	1.39

* FFT physicians are present in each year in every zip code area. GH and UH physicians are not always present. In 12% (hernia, surgery) to 53% (tonsillectomy) of the 4-digit zip code areas none of the patients in the corresponding two-digit zip code area visited a GH physician. In 0% (Cataract) to 41% (hip fractures) of the 4 digit zip code areas none of the patients in the corresponding two-digit zip code area visited a UH physician.

Table 4-C. Standard deviations physician density

Treatment	Specialty	UH standard deviation			GH standard deviation			FFT standard deviation		
		overall	between	within	overall	between	within	overall	between	within
Cataract	Ophthalmology	0.99	0.87	0.42	0.44	0.41	0.24	0.72	0.63	0.38
Tonsillectomy	Otolaryngology	0.80	0.73	0.26	0.40	0.37	0.20	0.53	0.47	0.26
Hernia	Neurology	1.35	1.17	0.60	1.11	1.07	0.43	1.09	1.00	0.48
Varicose veins	Dermatology	1.19	1.01	0.56	0.88	0.95	0.40	1.19	1.01	0.62
Varicose veins	Surgery	5.49	4.74	2.48	1.37	1.21	0.78	3.19	3.31	1.44
Inguinal hernia	Surgery	2.17	1.95	0.82	0.84	0.75	0.47	1.22	1.12	0.55
Arthrosis (knee)	Orthopedics	0.67	0.61	0.22	0.46	0.45	0.22	0.84	0.75	0.40
Arthrosis (hip)	Orthopedics	0.73	0.64	0.30	0.42	0.42	0.20	0.77	0.70	0.37
Hip fracture	Surgery	2.82	2.66	0.63	0.77	0.72	0.42	1.40	1.25	0.70

Table 4-D. The average percentage of physicians visited by patients, per type of physician (UH=university hospital, GH=general hospital, FFT=fee-for-treatment, UN=unknown)*

Treatment	Specialty	Average % visited																Average standard deviation			
		2006				*2007*				*2008*				*2009*				*2006-2009*			
		UH	GH	FFT	UN	UH	GH	FFT	UN	UH	GH	FFT	UN	UH	GH	FFT	UN	UH	GH	FFT	UN
Cataract	Ophthalmology	6	6	77	12	5	4	77	14	5	5	73	17	5	6	71	18	9.8	15.3	28.2	22.1
Tonsillectomy	Otolaryngology	4	5	84	7	4	5	79	11	4	4	78	14	4	4	80	12	7.9	14.1	27.4	22.6
Hernia	Neurology	3	15	71	11	4	15	69	12	3	21	60	16	3	17	65	15	9.5	27.7	34.2	22.3
Varicose veins	Dermatology	6	9	60	25	5	6	58	31	5	5	58	32	5	5	54	35	8.4	15.3	31.2	28.5
Varicose veins	Surgery	3	5	67	25	2	5	61	32	2	5	58	35	1	4	59	35	4.1	11.3	26.5	24.3
Inguinal hernia	Surgery	8	6	78	8	7	6	76	11	7	6	74	13	7	5	78	11	9.5	14.2	25.8	20.9
Arthrosis (knee)	Orthopedics	4	6	77	13	4	5	75	15	3	5	74	17	3	5	76	16	7.1	12.9	24.7	20.1
Arthrosis (hip)	Orthopedics	5	6	81	8	4	5	79	12	4	5	76	14	4	5	80	12	8.5	12.9	25.5	21.3
Hip fracture	Surgery	6	7	80	8	6	5	78	11	5	5	76	14	6	4	79	11	13.4	12.6	28.7	23.4
	Number of 2-digit areas (included in regression)	78				78				84				86							

* FFT physicians are present in each year in every zip code area. GH and UH physicians are not always present. In 12 percent (hernia, surgery) to 53 percent (tonsillectomy) of the four-digit zip code areas none of the patients in the corresponding two-digit zip code area visited a GH physician. In 0% (Cataract) to 41% (hip fractures) of the 4 digit zip code areas none of the patients in the corresponding two-digit zip code area.
In 45 percent (hip fractures) to 100 percent (varicose veins, surgery) of the two-digit zip code areas, at least one of the patients visited a hospital for which the number of physicians is unknown/unobserved.

Table 5: estimation results (cataract)

	(OLS)	*(RE)*	*(FE)*	*(TSLS)*
density_UH	14.44***	22.42***	49.68***	3.77
	(3.97)	(4.65)	(8.03)	(6.03)
density_GH	36.48***	33.45**	34.46***	70.03***
	(9.82)	(10.99)	(15.21)	(17.42)
density_FFT	106.32***	109.30***	116.29***	105.26***
	(6.51)	(7.25)	(11.34)	(12.24)
dummy 2007	0.63***	0.63***	0.78***	
	(0.10)	(0.09)	(0.14)	
dummy 2008	1.44***	1.45***	1.77***	0.82***
	(0.11)	(0.11)	(0.21)	(0.10)
dummy 2009	0.34**	0.42**	0.87***	-0.32**
	(0.12)	(0.12)	(0.25)	(0.11)
age75_80	0.99*	1.05*	0.98	1.38**
	(0.43)	(0.46)	(0.58)	(0.50)
age80_85	1.08*	1.00*	0.69	1.63**
	(0.44)	(0.47)	(0.57)	(0.51)
men	-0.02	-0.01	0.02	-0.01
	(0.04)	(0.01)	(0.13)	(0.05)
mortality	-0.02	-0.01	-0.01	-0.01
	(0.01)	(0.02)	(0.02)	(0.01)
westerns	-0.07***	-0.07***	0.03	-0.07***
	(0.01)	(0.01)	(0.08)	(0.01)
nonwesterns	0.03***	0.03**	-0.10	0.02**
	(0.01)	(0.01)	(0.08)	(0.01)
urbanized	-0.07	-0.07	1.18**	-0.05
	(0.06)	(0.08)	(0.42)	(0.08)
assistance	-0.00	-0.00	0.01	0.00
	(0.00)	(0.00)	(0.01)	(0.00)
working	-0.01	-0.01	-0.00	-0.01
	(0.01)	(0.01)	(0.04)	(0.02)
selfemployed	-0.03*	-0.03	-0.12	-0.03
	(0.01)	(0.02)	(0.09)	(0.02)
lowincome	-0.01	-0.01	-0.01	-0.03
	(0.01)	(0.02)	(0.02)	(0.02)
highincome	-0.00	-0.01	-0.03	-0.00
	(0.01)	(0.01)	(0.03)	(0.01)
waitingtime	-0.10***	-0.02	0.07**	-0.11***
	(0.02)	(0.02)	(0.02)	(0.02)
distGP	-0.12**	-0.13**	0.50	-0.14**
	(0.04)	(0.05)	(0.39)	(0.04)
av3GP	-0.00	-0.00	0.01	-0.00
	(0.01)	(0.02)	(0.09)	(0.02)
distGPcentre	-0.03**	-0.03*	-0.05	-0.02
	(0.01)	(0.01)	(0.19)	(0.01)
av20hospital	-0.04*	-0.05**	-0.56**	-0.06***
	(0.01)	(0.01)	(0.17)	(0.01)
constant	-11.00	-14.18	-21.48	-56.41
	(42.58)	(45.45)	(54.88)	(49.69)
Number of observations	11,036	11,036	11,036	8,013
Number of groups		3,061	3,061	
R^2	0.4831			0.4664
R^2 within		0.0915	0.1043	
R^2 between		0.6422	0.1144	
R^2 overall		0.4811	0.0942	

* significant at p<0.05; ** significant at p<0.01; *** significant at p<0.001

Table 6: autocorrelations and spatial correlations

Dependent variable: treatment density of 4-digit zip code areas

Treatment	Specialty	Autocorrelation (ρ_{AC})	Spatial Correlation (ρ_{SC}) 2006	2007	2008	2009	$\bar{y}$	MAE	$\hat{\sigma}_{\varepsilon}/\bar{y}$
Cataract	Ophthalmology	.38***	.75***	.61***	.59***	.62***	8.6	2.4	0.40
Tonsillectomy	Otolaryngology	.29***	.67***	.50***	.54***	.55***	3.5	1.3	0.50
Hernia	Neurology	.44***	.63***	.64***	.58***	.54***	3.0	1.2	0.60
Varicose veins	Dermatology	.71***	.83***	.90***	.89***	.90***	2.9	1.8	0.84
Varicose veins	Surgery	.38***	.50***	.57***	.60***	.55***	1.9	0.9	0.68
Inguinal hernia	Surgery	.11***	.36***	.18***	.18***	.18***	1.8	0.7	0.57
Arthrosis (knee)	Orthopedics	.34***	.62***	.63***	.58***	.56***	2.0	0.9	0.65
Arthrosis (hip)	Orthopedics	.13***	.27***	.21***	.17***	.19***	1.4	0.6	0.67
Hip fracture	Surgery	.58***	.28***	.27***	.28***	.34***	0.5	0.4	1.33
Number of zip code areas		7,965	2,588	2,620	2,842	2,908		11,036	

* significant at $p<0.05$; ** significant at $p<0.01$; *** significant at $p<0.001$ (based on robust standard errors)

Table 7-A: results of OLS, RE, and FE estimations

dependent variable: 4-digit treatment density (N=11,036)

Treatment	Specialty	UH			GH			FFT		
		(OLS)	*(RE)*	*(FE)*	*(OLS)*	*(RE)*	*(FE)*	*(OLS)*	*(RE)*	*(FE)*
Cataract	Ophthalmology	0.05***	0.07***	0.17***	0.12***	0.11**	0.12*	0.36***	0.37***	0.39***
Tonsillectomy	Otolaryngology	0.12***	0.13***	0.18***	0.17***	0.19***	0.20***	0.50***	0.51***	0.50***
Hernia	Neurology	-0.04*	-0.02	0.10**	0.31***	0.31***	0.33***	0.61***	0.58***	0.51***
Varicose veins	Dermatology	0.33***	0.26***	0.20***	0.24***	0.09**	-0.16***	0.56***	0.36***	0.20***
Varicose veins	Surgery	0.05***	0.04**	0.03	0.33***	0.31***	0.13	0.53***	0.46***	0.17***
Inguinal hernia	Surgery	0.11***	0.13***	0.21***	0.15**	0.16**	0.19*	0.38***	0.41***	0.57***
Arthrosis (knee)	Orthopedics	0.05	0.06	0.17**	0.71***	0.55***	0.09	0.44***	0.44***	0.38***
Arthrosis (hip)	Orthopedics	0.19***	0.19***	0.07	0.48***	0.48***	0.52***	0.49***	0.49***	0.57***
Hip fracture	Surgery	0.15***	0.14***	0.09	-0.03	-0.04	-0.02	0.26***	0.25***	0.21**
Average effect (all treatments)		0.11	0.11	0.14	0.28	0.24	0.16	0.46	0.43	0.39

*significant at p<0.05; ** significant at p<0.01; *** significant at p<0.001 (based on robust standard errors)

Table 7-B: results of TSLS estimation with lagged densities as instruments

dependent variable: 4-digit treatment density (N=8,013)

Treatment	Specialty	UH	GH	FFT
		(TSLS)	*(TSLS)*	*(TSLS)*
Cataract	Ophthalmology	0.01	0.23***	0.35***
Tonsillectomy	Otolaryngology	0.07*	-0.03	0.36***
Hernia	Neurology	-0.06	0.35***	0.72***
Varicose veins	Dermatology	0.42***	0.31***	0.79***
Varicose veins	Surgery	0.04*	0.08	0.66***
Inguinal hernia	Surgery	0.08	0.20	0.33**
Arthrosis (knee)	Orthopedics	-0.03	0.84***	0.28***
Arthrosis (hip)	Orthopedics	0.27***	0.52***	0.58***
Hip fracture	Surgery	0.15***	0.17	0.25*

*significant at p<0.05; ** significant at p<0.01; *** significant at p<0.001 (based on robust standard errors)

Table 8-A. Robustness check physician density

Dependent variable: 4-digit treatment density (N=11,036)

Treatment	Specialty	η_{FFT-GH} (OLS)	η_{FFT-GH} (RE)	η_{FFT-GH} (FE)	η_{FFT-UH} (OLS)	η_{FFT-UH} (RE)	η_{FFT-UH} (FE)	η_{FFT-UN} (OLS)	η_{FFT-UN} (RE)	η_{FFT-UN} (FE)
Cataract	Ophthalmology	0.15***	0.19***	0.27***	0.70***	0.75***	3.43***	-0.01	-0.01	0.01
Tonsillectomy	Otolaryngology	0.20***	0.24***	0.42***	0.51***	0.57***	1.67***	-0.06**	-0.07**	-0.07**
Hernia	Neurology	0.24***	0.22***	0.17**	0.99***	1.02***	1.48***	0.01	0.02	0.00
Varicose veins	Dermatology	0.56***	0.21***	-0.11*	-0.05	0.90***	3.90***	-0.45***	-0.38***	-0.26***
Varicose veins	Surgery	0.07	0.06	0.19	1.51***	1.23***	0.53	-0.31***	-0.23***	0.03
Inguinal hernia	Surgery	0.15**	0.16**	0.15	0.10	0.12	1.62***	0.03	0.02	-0.04
Arthrosis (knee)	Orthopedics	-0.19***	0.09	0.81***	1.00***	1.08***	1.97***	-0.07*	-0.01	0.11*
Arthrosis (hip)	Orthopedics	-0.02	-0.02	0.05	0.42***	0.44***	2.05***	-0.07*	-0.07*	-0.05
Hip fracture	Surgery	0.23*	0.23	0.18	-0.14	-0.07	0.31	-0.09	-0.08	-0.08
Average effect (all treatments)		0.15	0.15	0.24	0.56	0.67	1.88	-0.11	-0.09	-0.04

*significant difference at p<0.05; ** significant difference at p<0.01; *** significant difference at p<0.001 (based on robust standard errors)

Table 8-B.

Dependent variable: 4-digit treatment density (N=11,036)

Treatment	Specialty	$\hat{\xi}_{FFT} - \hat{\xi}_{GH}$ (see Table 7-A) (OLS)	(RE)	(FE)	$\hat{\xi}_{FFT} - \hat{\xi}_{UH}$ (see Table 7-A) (OLS)	(RE)	(FE)
Cataract	Ophthalmology	0.24***	0.26***	0.27***	0.31***	0.30***	0.22***
Tonsillectomy	Otolaryngology	0.33***	0.32***	0.30***	0.38***	0.38***	0.32***
Hernia	Neurology	0.30***	0.27***	0.18***	0.65***	0.60***	0.41***
Varicose veins	Dermatology	0.32***	0.27***	0.36***	0.23***	0.10**	0.00
Varicose veins	Surgery	0.20***	0.15**	0.04	0.48***	0.42***	0.14**
Inguinal hernia	Surgery	0.23***	0.25***	0.38***	0.27***	0.28***	0.36***
Arthrosis (knee)	Orthopedics	-0.27***	-0.11	0.29**	0.39***	0.38***	0.21**
Arthrosis (hip)	Orthopedics	0.01	0.01	0.05	0.30***	0.30***	0.50***
Hip fracture	Surgery	0.29**	0.29**	0.23	0.11*	0.11*	0.12
Average effect (all treatments)		0.18	0.19	0.23	0.35	0.32	0.25

*significant difference at p<0.05; ** significant difference at p<0.01; *** significant difference at p<0.001 (based on robust standard errors)

Table 9. Robustness checks treatment density

Treatment	Specialty	3-digit zip codes (N=2,839)			Border areas excluded (N=7,926)		
		(UH)	*(GH)*	*(FFT)*	*(UH)*	*(GH)*	*(FFT)*
Cataract	Ophthalmology	0.16***	0.12	0.38***	0.13**	0.03	0.28***
Tonsillectomy	Otolaryngology	0.23***	0.17**	0.48***	0.12**	0.19***	0.45***
Hernia	Neurology	0.08*	0.37***	0.53***	0.02	0.44***	0.49***
Varicose veins	Dermatology	0.19***	-0.15***	0.20***	0.14***	-0.07	0.26***
Varicose veins	Surgery	0.00	0.08	0.14*	0.02	0.16*	0.21***
Inguinal hernia	Surgery	0.19***	0.12	0.57***	0.17**	0.14	0.51***
Arthrosis (knee)	Orthopedics	0.10	-0.06	0.36***	0.27**	0.12	0.39***
Arthrosis (hip)	Orthopedics	0.05	0.46***	0.57***	-0.02	0.58***	0.56***
Hip fracture	Surgery	0.20**	-0.04	0.32***	0.02	0.00	0.27**

* significant at p<0.05; ** significant at p<0.01; *** significant at p<0.001 (based on robust standard errors)

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