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The impact of regulatory changes on the providers of treatment for opioid dependence

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THE IMPACT OF REGULATORY CHANGES ON THE PROVIDERS OF TREATMENT FOR OPIOID DEPENDENCE

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DEDICATION

This work is dedicated to my wife, Lauren. Without her support, I could never (and would never) have finished this. I also dedicate this work to our son, Owen, and his little brother Simon (forthcoming), as well as to all of our future children.

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CHAPTER 1: INTRODUCTION

1.1 STATEMENT OF THE PROBLEM

Drug abuse is a serious problem in the United States. According to the Substance Abuse and Mental Health Services Administration (SAMHSA), in 2007 about 3.7 percent of the U.S. population aged twelve years old or older (9.3 million people) were current illicit drug users who used drugs other than marijuana (the most commonly used illicit drug) (SAMHSA, 2008). Chronic drug users are also likely to be the perpetrators and victims of criminal activity (French, et al., 2004); chronic drug users also use more inpatient and emergency care than others (French, et al., 2000).

Illicit drug users abusing prescription pain relievers—including opioid pain relievers such as Oxycontin, Percocet, Tylox, Percodan, hydrocodone, and morphine—were estimated to stand at 5.2 million, or 2.1 percent of the population twelve years old or older. This is a statistically significant increase from the 2004 rate of 1.8 percent. The number of current heroin users in 2007 fell to only 0.06 percent of the twelve-or-older population, down from 0.14 percent in 2006. Prescription opioids are the primary substance of abuse for 18% of substance abuse treatment admissions (SAMHSA, 2006).

Opioid abuse is serious not only because of its prevalence but also because of its toll. In 2006, 38 of the metropolitan areas covered by the Drug Abuse Warning Network (DAWN) had 30 or more drug-related deaths (Ball & Albright, 2009). In all but three of these metropolitan areas, opiates and other opioids were involved in more deaths than any other drug. In each of the three metropolitan areas where opiates/opioids were not involved in the most drug-related deaths, they were a close second; cocaine was involved in fewer than ten more deaths. The urgency of combating opioid dependence to reduce the number of drug-related deaths can be illustrated by noting that heroin—despite its low prevalence and its being involved in the fewest of the opiate/opioid-related deaths reported by DAWN—is still, in many metropolitan areas, involved in more than 5 percent of drug-related deaths.

A treatment gap remains for opioid addicts (Kissen, et al., 2006). Admissions for primary heroin abuse increased by 11% from 1995 – 2005, but planned medication-assisted therapy decreased by almost 30% (SAMHSA, 2007). Studies have shown that the most effective way to treat opioid dependence is with opioid agonist treatment, wherein the drug of abuse is replaced with a similar opioid that prevents withdrawal symptoms and even the euphoric effects of the drug of abuse (Mattick, 2009). Historically, licensed opioid treatment programs (OTPs), or "methadone clinics", have been the only source of this kind of effective treatment against opioid dependence. Methadone maintenance works well (Ling & Wesson, 2003), but it is subject to several drawbacks. First, it is time consuming, requiring patients to travel as frequently as daily to methadone clinics where they received doses of methadone. This time cost is important to patients seeking treatment (Borisova & Goodman, 2004). Secondly, methadone is a full-agonist at μ-receptors, which means that patients can develop a dependence on methadone and that methadone overdoses can be fatal. Thirdly, office-based treatment (as opposed to methadone clinic treatment) brings in patients not usually seen in methadone clinics who are more likely to be young, white and hepatitis-C negative (Sullivan, et al., 2005).

The Narcotic Addiction Treatment Act of 1974 (NATA 1974) addressed the serious issue of diversion of methadone by creating a complicated regulatory structure—allowing only approved programs the ability to provide narcotic medications for drug addiction treatment. The Drug Addiction Treatment Act of 2000 (DATA 2000), however, allows physicians to receive a waiver from these regulations for the purpose of prescribing and dispensing FDA-approved

Schedule III, IV and V narcotic medications for treatment of opioid dependence. The only drugs in these schedules that are approved by the FDA for the treatment of opioid dependence are Subutex and Suboxone, sublingual high-dose preparations of buprenorphine. The federal regulation of the use of methadone in OTPs remains unchanged by DATA 2000.

Buprenorphine is a partial agonist that produces a weaker opioid effect. Because of its weaker opioid effect, it can be prescribed by a doctor and self-administered by patients, thus eliminating most of the time cost associated with the use of methadone for treatment of opioid dependence. Other potential benefits of buprenorphine include an easier withdrawal, a reduced chance of fatal overdoses, and a lower likelihood of abuse by patients or diversion to abuse by non-patients.

The provision of the waivers introduced by DATA 2000, by allowing office-based physicians to treat opioid dependence with the use of buprenorphine, marks an historic turning point in the treatment of opioid dependence in the U.S. The relative openness of the provision of waivers (compared to the tight regulation under NATA 1974) also potentially brings into the substance abuse treatment community many physicians not otherwise professionally concerned with substance abuse treatment; any physician, regardless of their specialty or their practice setting, can qualify for a waiver.

Complicating matters, however, is a 30-patient caseload maximum placed on office-based physicians treating opioid dependent patients with buprenorphine under such a waiver (Stanton, et al., 2006). Originally, there was a 30-patient limit on physicians and group practices. The restriction on group practices was removed in August 2005, so that the caseload maximum limit is now a per-physician limit. The restrictions changed again at the very end of 2006 to allow physicians to treat up to 100 patients once the physician has a year of experience and files a second notification with the DEA. This caseload max is central to the present study. OTPs may use buprenorphine without a DATA 2000 waiver, and are thus not subject to the 30-patient or 100-patient limit. The purpose of this restriction is to curb diversion to abuse, which was the intention of NATA 1974.

Though the effectiveness of and issues related to office-based treatment of opioid dependence with buprenorphine have been explored in the substance abuse treatment literature, there has not been any work in the field of economics to model and understand physician behavior in this context, especially physician response to a caseload maximum. This study attempts to provide some understanding.

1.2 THE SCOPE OF THE STUDY

This study examines the behavior of office-based physicians using buprenorphine to treat opioid dependence. This study seeks to explore whether physician differences reveal themselves through different behaviors, specifically physician choices regarding the prescription of buprenorphine to opioid dependent patients in the face of a caseload maximum. In particular, physicians have to make a decision about whether to use buprenorphine only to help patients discontinue the substance of abuse, or to keep the patient on buprenorphine indefinitely and maintain a long-term relationship with the patient (“maintenance”). Many observable physician differences may contribute to the physician’s choices over these two treatment paths.

Physicians become qualified to receive a waiver under DATA 2000 if they hold one of a number of certifications related to addiction or if they complete an approved eight-hour training course. The eight hours of training is likely to be the most attractive route for physicians not otherwise professionally involved in the treatment of addiction. These training courses are offered in person or electronically, via CD-ROM over the internet. On-line/CD-ROM-based training courses are offered by the American Society of Addiction Medicine and the American Academy of Addiction Psychiatry for $175 and $189 respectively. There is no reason to believe that this cost is in any way prohibitive for physicians. Furthermore, these training courses (both in person and electronic) qualify for *AMA PRA Category 1 Credit*™—credit for continuing medical education (CME) that many physicians earn as required by their state licensing boards, medical specialties societies or boards, hospital staffs, or insurance groups.

Holding a board certification in addiction medicine, on the other hand, demonstrates a professional commitment to the treatment of substance abuse. At the minimum, it can be expected that the typical physician holding a board certification may approach the office-based treatment of opioid dependence differently than the typical physician who received only eight hours of online training.

The perceived benefit to physicians can also be affected by demographic characteristics. Some physicians may consider it likely that they will encounter suitable opioid dependent patients in need of treatment on a regular basis; others may consider this unlikely. In the face of a caseload maximum, this likelihood could affect physician behavior.

Perceived costs may differ as well. Among physicians who do not specialize in addiction medicine, differences in specialty may contribute to different choices regarding the treating of opioid dependence with buprenorphine. Specialties differ by the amount of training involved, average number of hours worked, average income earned, and the skills or temperament required. Since specialty choice is endogenous, specialty choice should reveal differences among physicians, and that these differences might also impact choices related to treatment of opioid dependence. If it is the case that certain treatment paths are more time-intensive than others, or that certain treatment paths are more profitable than others, perceived opportunity costs (in terms of forgone income and forgone leisure) will therefore also differ.

Physician practice setting can impact the costs of providing substance abuse treatment as well. Some practice settings may be more or less appropriate for the treatment of drug-addicted patients, due to the potential interaction with other patients, or due to proximity of appropriate counseling and other non-pharmaceutical therapies opioid dependent patients may need in addition to buprenorphine treatment.

This study considers the practicality of closing the treatment gap in opioid dependence by allowing office-based non-addiction-specializing physicians to treat opioid dependence using buprenorphine. It does not judge the appropriateness of such an approach—the substance abuse community is best-suited for that evaluation and has consistently embraced the approach—but rather to discover and explore differences in the ways that physicians respond to new treatment (and potential profit) opportunities as well as the federal regulations that govern them.

1.3 FINDINGS

Following the introductory chapter, there are seven more chapters. Chapter 2 is a review of the relevant literature on the treatment of opioid dependence with buprenorphine, including the proper protocols for prescribing and dispensing buprenorphine. Absent any compelling reason not to, the National Institutes of Health encourages physicians to treat opioid dependence with buprenorphine using long-term maintenance, rather than withdrawing patients from buprenorphine once stable. This chapter also covers the waiver process, and highlights the ease with which physicians can become certified to prescribe buprenorphine, as well as the ease with which physicians can increase their caseload maximum from 30 to 100.

Chapter 3 is a review of the economic literature regarding physician behavior with a particular focus on the topic of supplier-induced demand (SID), sometimes also called physician-induced demand (PID). The present study avoids many of the pitfalls of previous studies that incorporated supplier-induced demand, though making a case for or against the existence of supplier-induced demand is not the focus of the present study.

The algebraic model is presented in Chapter 4. This model simplifies physician choice with respect to treatment of opioid dependence to two decisions: the choice of a price/quantity schedule for taking on new opioid dependent patients, and the choice of an optimal fraction of those patients successfully stabilized who will undergo maintenance treatment. Kuhn-Tucker conditions give rise to three experiments in particular: one related to the number of patients on maintenance, one related to the number of non-maintenance patients, and one related to differences brought about by the change in the caseload maximum in the total numbers of patients.

Chapters 5 and 6 present the data: its sources, the characteristics of the sample, its limitations and the methods used for variable creation. In Chapter 6, tests for heteroskedasticity in the data and two approaches for dealing with it are also discussed.

The results of the empirical testing are discussed in Chapter 7. Three experiments are done: one on the number of maintenance patients (Experiment #1), one on the number of non-maintenance patients (Experiment #3), and one on the differences in the total numbers of patients after a change in the caseload maximum (Experiment #2). In general, the results of the three experiments confirm the predictions of the algebraic model presented in Chapter 4. Physician specialty appears to reveal much about physician market power and opportunity costs. Physicians in primary-care-type specialties (like internal medicine, family medicine and pediatrics) treat more patients than do physicians in other specialties. Physicians who are certified in addiction medicine, report addiction medicine as a primary specialty or report dedicating a high percentage of their practices to treating patients for substance abuse also treat more patients, suggesting that they face lower opportunity costs. Practice setting appears to reveal less about market power and opportunity cost, so there are only limited results that link practice setting to physician treatment choices. The empirical results from Chapter 7 overwhelmingly support the result that physicians will treat more patients as a result of an increase in the caseload maximum, but that this effect is stronger for maintenance.

Chapter 8 presents a summary of the study and its conclusions. The implications for policy and for substance abuse treatment are discussed, and suggestions are made for further research.

CHAPTER 2: OPIOID ADDICTION TREATMENT WITH BUPRENORPHINE

2.1 TREATMENT PROTOCOLS

The Office of Evaluation, Scientific Analysis and Synthesis of the CSAT publishes Treatment Improvement Protocols (TIPs) to provide best practice guidelines for the treatment of substance abuse. TIP 40, entitled "Clinical Guidelines for the Use of Buprenorphine in the Treatment of Opioid Addiction" (CSAT 2004) offers recommendations on the use of buprenorphine in clinical settings based on the experiences and the research of experts in the field. This section will summarize the recommendations in the TIP that pertain to physician choice within the scope of the current study.

Buprenorphine is currently commercially available in two medications: Subutex and Suboxone. Both are sublingual tablets, and both come in 2mg and 8mg doses. Subutex is buprenorphine only; Suboxone is four parts buprenorphine and one part naloxone. Naloxone is added to make the abuse of Suboxone undesirable, as it should block the opioid effect of the injection of crushed Suboxone tablets, and perhaps even precipitate withdrawal symptoms. The combination of buprenorphine and naloxone is referred to generally as "combination therapy," though currently it only exists under the trade name Suboxone. The CSAT recommends that combination therapy be used whenever possible, and only suggests the use of "monotherapy" (buprenorphine alone) in a few cases, such as when the patient is a pregnant woman.

The clinical use of buprenorphine to treat opioid dependence can involve the following phases: *tapering*, wherein dosages of the opioid on which the patient is dependent are reduced; *induction*, wherein the patient is first switched to buprenorphine; *stabilization*, wherein the patient is monitored to ensure the successful switch from the drug of abuse to buprenorphine; *maintenance*, wherein other issues related to or arising from drug abuse (such as psychosocial and family issues) are addressed; and *dose reduction*, where dosages of buprenorphine are tapered until the patient finally discontinues the use of buprenorphine. Exactly which of these phases treatment will actually involve hinges on two primary factors: whether the patient is seeking to discontinue the use of a long-acting opioid (like methadone) or a short-acting opioid (like heroin or Oxycodone), and whether the physician chooses to withdraw the patient from buprenorphine after the patient is stabilized or to maintain the patient on buprenorphine for an extended period of time.

For patients discontinuing the use of a long-acting opioid, such as methadone, they must first taper their usual dose to no more than 30mg daily before they can be switched to buprenorphine. This tapering is not necessary for a patient using a short-acting opioid; these patients should simply discontinue use and be switched to buprenorphine[1]. If the physician chooses to immediately withdraw a patient, there will be no *maintenance phase*. If the physician chooses to use buprenorphine for long term maintenance, there may or may not be a *dose reduction* phase, as some patients may stay on buprenorphine indefinitely. If a patient’s doses of buprenorphine are reduced and the patient is taken off of buprenorphine, this constitutes withdrawal, whether or not the patient had previously been maintained. Many in the substance abuse treatment community use the word “detoxification” in place of “withdrawal.” Table 2.1 summarizes the phases of treatment under the four possible circumstances.

[1] If a patient is discontinuing the use of a long-acting opioid, the physician is encouraged to use monotherapy (Subutex) when initially switching the patient to buprenorphine, and then to use combination therapy (Suboxone) as soon as possible thereafter; patients discontinuing short-acting opioids should only be treated with combination therapy.

In Chapter 4, the physician's choices about the number of patients to take on and the fraction to keep on maintenance will be the dependent variables. Regarding this choice, TIP 40 summarizes:

> "The preponderance of research evidence and clinical experience, however, indicates that opioid maintenance treatments have a much higher likelihood of long-term success than do any forms of withdrawal treatment. In any event, the immediate goals in starting buprenorphine should be stabilization of the patient and abstinence from illicit opioids, rather than any arbitrary or predetermined schedule of withdrawal from the prescribed medication."

Despite this warning about predetermined schedules, it is difficult to believe that physician-specific differences such as specialty, practice setting, etc., will not at least in part influence treatment choice.

TABLE 2.1 – The phases of clinical treatment of opioid dependence with buprenorphine.

		Physician-determined treatment approach		
		Withdrawal	**Maintenance then Withdrawal**	**Maintenance**
Opioid of abuse	**Long-acting**	*Tapering*, *Induction*, *Stabilization*, and *Dose Reduction*	*Tapering*, *Induction*, *Stabilization*, *Maintenance*, and *Dose Reduction*	*Tapering*, *Induction*, *Stabilization*, and *Maintenance*
	Short-acting	*Induction*, *Stabilization*, and *Dose Reduction*	*Induction*, *Stabilization*, *Maintenance*, and *Dose Reduction*	*Induction*, *Stabilization*, and *Maintenance*

2.2 THE EFFICACY OF BUPRENORPHINE FOR TREATMENT OF OPIOID DEPENDENCE

Many studies have confirmed the efficacy and safety of buprenorphine (Mello & Mendelson, 1985; Walsh & Eisenberg, 2003; Ling, et al., 1998), even in outpatient and primary care settings (Fiellin, et al., 2006; Fedula, et al., 2003; Sohler, et al., 2010; Soeffing, et al., 2009). With respect to retention and suppression of heroin use, it can be as effective as methadone (Mattick, 2008). Both patients and physicians perceive buprenorphine to be effective (Stanton, et al., 2006), and buprenorphine is significantly cheaper than methadone treatment. French, et al. (2008) have shown that non-methadone outpatient treatment costs $2,325 per treatment episode while methadone maintenance costs over 3 times as much. Probably because of its cost-effectiveness and efficacy, there is significant interest in prescribing buprenorphine, even among nurse practitioners and physicians' assistants (Roose, et al., 2008).

Buprenorphine use in treatment of opioid dependence is not without downsides. Among many physicians there still exists mistrust of substance-abusing patients, and there is no standard for treating pain for opioid dependent patients (Merrill, et al., 2002). Financial considerations also matter. Buprenorphine is excluded from 31% of insurance product formularies, and is in the highest-cost tier in 55% of formularies (Horgan, et al., 2008). Netherland, et al. (2009) have documented that training and reimbursement remain cromulent sources of difficulty for physicians prescribing buprenorphine, as does access to counseling services. Proper treatment in most cases requires maintenance and follow-up with other counseling services (SAMHSA, 2004; Fiellin, et al., 2004).

2.3 CSAT WAIVERS

Title XXXV of the Children's Health Act of 2000, otherwise known as The Drug Addiction Treatment Act of 2000 (DATA 2000), modified the Controlled Substances Act to allow physicians to receive a waiver from the usual prohibition of the use of Schedule III, IV or V narcotics for the treatment of opioid dependence. Opioid treatment programs (OTPs) or "methadone clinics" are regulated under the Narcotic Addict Treatment Act of 1974, and do not require additional permissions to use buprenorphine treatment to treat opioid dependence. Only physicians outside of these or other tightly-regulated in-patient treatment facilities require such a waiver.

In order to qualify for a waiver under DATA 2000, a physician (either an M.D. or D.O.) must demonstrate necessary training, background or experience in addiction medicine broadly or treatment of opioid dependence with buprenorphine specifically, demonstrate the ability to refer opioid dependent patients to other psychosocial services (such as group or individual therapy), and agree not to carry a caseload of patients being treated with buprenorphine that exceeds a certain maximum, initially set at 30 patients and then increased to 100 patients after one year of prescribing buprenorphine. The necessary training, background or experience is demonstrated by one or more of the following:

- The physician holds a subspecialty board certification in addiction psychology from the American Board of Medical Specialties.
- The physician holds an addiction treatment certification from the American Society of Addiction Medicine.
- The physician holds a subspecialty board certification in addiction medicine from the American Osteopathic Association.
- The physician participated as an investigator in one or more clinical trials which led to the approval of a Schedule III, IV or V narcotic for the treatment of opioid dependence.

- The physician has received other training or experience that is approved by that physician's state medical licensing board or the Department of Health and Human Services.
- The physician has completed at least eight hours of approved training in the treatment and management of opioid addicted patients[2].

A physician seeking a waiver first notifies the Secretary of Health and Human Services of intent to treat patients with buprenorphine. The notification form can be completed and submitted online or faxed or mailed in. The recipient of this notification within the Department of Health and Human Services is the Division of Pharmacologic Therapies (DPT) within the Center for Substance Abuse (CSAT) within the Substance Abuse and Mental Health Services Administration (SAMHSA). After receiving this notification, CSAT reviews the notification and determines whether the physician meets the criteria for a waiver then notifies the Drug Enforcement Agency (DEA) that the physician is qualified. The DEA issues to the physician a unique identification number indicating the physician's qualifications. (These waivers are often referred to as "CSAT waivers.")

In late 2006, Title XI of the Office of National Drug Control Policy Reauthorization Act further amended the Controlled Substances Act by granting physicians the opportunity to seek permission to treat up to 100 patients, so long as the physician currently has a CSAT waiver and it has been one year since they filed their initial notification with CSAT. In order to increase the patient limit, a physician files a second notification with CSAT indicating intent to treat up to 100 patients. Because the requirements for the patient caseload increase

[2] Approved training can be provided by the American Academy of Addiction Psychiatry, the American Medical Association, the American Osteopathic Academy of Addiction Medicine, the American Psychiatric Association, the American Society of Addiction Medicine, or other organizations approved by the Secretary of Health and Human Services.

are simple and easily understandable, the *submission* of a second notification permits the physician to begin treating more patients; the physician does not need to wait for CSAT confirmation. Physician response to an increase in the allowable patient caseload maximum is a primary focus of this study.

CHAPTER 3: PHYSICIAN BEHAVIOR AND SUPPLIER-INDUCED DEMAND

3.1 PHYSICIAN BEHAVIOR

The data presented in Chapter 5 and analyzed in Chapters 6 and 7 provide the ability to compare physicians along several important dimensions, including primary specialty and practice setting. This section will provide a brief review of the literature with respect to these important physician-level variables.

The issue of physician specialty has been studied extensively in the literature. The four variables that are most usually analyzed in relation to specialty choice are educational indebtedness, specialty potential earnings, years of graduate medical education required and number of work hours. Bazzoli (1985) showed that educational indebtedness can affect specialty choice, but that the impact is modest. It could be that physicians address the issue of educational indebtedness through other labor market decisions, like the decision to moonlight while in residency (Culler and Bazzoli, 1985).

There is a general consensus in the literature that the effect of potential earnings on likelihood of specialty choice is positive but modest. Hadley (1977) failed to find an impact at all, but Bazzoli (1985) and Sloan (1970) found a small but statistically significant effect from income, such that physicians were more likely to choose specialties that offered higher potential earnings. McKay (1990) showed that the percent of residents in a specialty increased less-than-proportionately when relative earnings for that specialty increased. When examining the variance in recent trends (from late 1990s to early 2000s) in specialty choice, Dorsey et al. (2003) found that income explained only 9% of the overall variability.

The literature fails to find a consistent effect from the number of years of graduate medical education required in a specialty. McKay (1990) found that length of training did not matter, and Dorsey et al. (2003) found that years of required education explained 0.3% of the variability in recent trends in physician choice—but in the counterintuitive direction. Physicians appeared to have a preference for specialties that required 4 or more years of graduate medical education, even after controlling for income.

Dorsey et al. (2003) also found, somewhat surprisingly, that number of expected work hours explained 1% of the variability in specialty choice, with physicians demonstrating a preference for specialties with more work hours (even after controlling for income). McKay (1990) found, however, the contrary result: that the percentage of residents choosing a particular specialty increases more than proportionately when the relative number of hours worked decreases.

The study by Dorsey et al. also identified another variable useful in distinguishing specialties: controllable lifestyle. Fifty-five percent of the variability in trends in specialty choice was explained by physicians revealing a preference for a controllable lifestyle. Despite the inconsistent nature of some of these results, two general conclusions emerge: physician specialty choice is endogenous, and reflects careful consideration by residents and medical school students of many variables; potential income explains some, but certainly not all, of a physician's choice of medical specialty.

The fact that non-pecuniary considerations are important factors in the choice of specialty is underscored by the results of Burstein and Cromwell's (1985) study on the rates of return from training of U.S. physicians. They found that the pediatricians in their study received negative real rates of return from their specialty training. The fact that physicians chose a specialty with a negative rate of return suggests that lifestyle or other considerations are important.

Physician specialty may also reveal something about the market structure in which the physician operates, which will be an issue in the discussion in the next section of demand inducement. Wong (1996) showed that the market for many physician services was likely to be monopolistically competitive, but that the reliability of that result depended on the specialty under investigation. That conclusion held well for primary care physician services, as well as the markets for general and family practice services and general surgery. For internal medicine, the results were less conclusive, though monopoly structure was successfully ruled out. After adjusting his model to correct some empirical problems, Wong found stronger evidence that the market for internal medicine is likely characterized by monopolistic competition, but with "informational confusion," whereby rising physician supply increases search costs, which put net upward, not downward, pressure on prices. So in addition to providing some information about the physician, specialty also provides information about the market structure in which the physician's practice operates.

David and Neuman (2011) have recently explored the division of labor among physicians between different practice settings. Their findings indicate that when physicians have the ability to split patients between different practice settings, that decision hinges on considerations such as the complexity of the patient's case, the risk of serious complication, and the distance of the practice setting from a hospital. The important implication for the model discussed in Chapter 4 is that physician practice setting is also a part of the bundle of a priori physician choices that bear on the physician's decisions about treating patients. Further, the authors point out that this can result in cream-skimming, whereby low-risk patients are moved from hospital settings and into other separated practice settings, leaving hospitals with higher risk (and higher cost) patients.

The final physician-specific variable of interest is board certification. Wilensky and Rossiter (1983) showed that board eligibility raised incomes on average by $8,000 per year, while board certification raised incomes on average by $13,000. The differential effect of board certification versus board eligibility is interpreted by the authors as reflecting differences such as improved referrals and staffing privileges, and not simply the result of procedure-specific training.

3.2 SUPPLIER-INDUCED DEMAND

The model presented in Chapter 4 assumes that the physician faces a downward-sloping demand curve for detoxification treatment and then induces demand for follow-up, or maintenance, treatment. Supplier-induced demand (SID) is a controversial topic, and special attention is given to it here. The recognition of the phenomenon is generally traced back to Evans (1974) who observed that physician incomes in British Columbia did not vary the way that physician supply did. Evans concluded that physicians must be adjusting their treatment intensity in order to prevent income from changing, even if patient caseloads did change.

In this section, a summary of the current literature on SID will be presented, starting first with the various definitions of SID, then moving on to the findings of the SID literature; the next section presents the assumptions of the model presented in Chapter 4 in light of the discussion of SID in this chapter.

3.2.1 DEFINING SUPPLIER-INDUCED DEMAND

The definition of SID is important because it has serious economic implications. The ability of physicians to influence the demand for the medical services they produce has a twofold origin: information asymmetry and third-party payment. It is information asymmetry that makes demand inducement possible. Most patients do not have the medical expertise to appraise the necessity of certain medical treatments. In this way, the physician/patient relationship can be modeled much like the mechanic/customer relationship and other professional services agent/principal relationships. The agent offers a recommendation to the principal who must assess how well the agent’s goals line up with his or her own goals and the likelihood that the recommendation is a good one, given the constraints on the agent such as the costs of making spurious recommendations (e.g., bad reputation). The presence of third-party payers exacerbates this problem, however, by reducing the cost to patients of allowing themselves to be induced into purchasing something they do not need.

Generally, SID is modeled as imperfect agency on the part of the physician. The physician engages in SID when he or she recommends medical care that has a marginal health benefit that is lower than its marginal cost only because the impact on physician net income is positive. The exact nature of this process is described differently by different researchers. Some model SID as a game of cheap talk (Calcott, 1999; De Jaegher and Jegers, 2001); others consider the possibility of fraud on the part of the physician (Wolinsky, 1993); still others describe it as a physician’s rational participation in the patient’s search process (Rochaix, 1989). Ellis and McGuire (1990) have pointed out that third-party payment schemes can often cause quantity demanded and quantity supplied to differ, and the actual amount of medical care provided in the market is a function of the relative bargaining power of patient and physician. SID in this case is simply an expression of the physician's relative bargaining power. Data that indicate the patient's relative bargaining power are generally not available.

The nature of the SID is likewise defined differently by different researchers. Some have focused on visit intensity (Delattre and Dormont, 2003), while others have focused on physician-initiated (as opposed to patient-initiated) visits (Wilensky and Rossiter, 1983; Grytten, et al., 1995). Most of the literature takes a negative view of the practice of demand inducement by assuming that the induced treatment is known by the physician to be unnecessary or unhelpful. Reinhardt (1985) asserts that the suggestion that demand inducement will be in the long run fully exploited if the possibilities for it are finite amounts to a claim that physicians are without conscience. The point is that SID is such shameful behavior that only the conscience-less would fully exploit it. Richardson (2001) interestingly points out that the provision of more care may be, in some cases, provision of better care in the mind of the physician, who is trained in many cases to believe that more care is better. Typical workload constraints prevent the provision of more intense care, but shrinking caseloads—perhaps in response to increases in physician supply—provide the physician with sufficient time to provide more intense care. Finally, Carlsen and Grytten (2000) conclude that SID, if it does exist, does not pose a problem because it leads to greater patient satisfaction. If the demand curve for physician services is shifted outward (even through demand inducement), then consumer surplus is higher.

The definition of SID that is employed in the model presented in the next chapter is a simple one: supplier-induced demand represents the physician's ability, through whatever means, to convince a patient to receive treatment of a specific type—or to deny a patient treatment of a specific type—without losing that patient as a customer for other types of care.

3.2.2 FINDING SUPPLIER-INDUCED DEMAND

Attempts to identify SID empirically have generated mixed results. Many studies have supported the existence of SID (Folmer and Westerhout, 2008; Melichar, 2009; Schaafsma, 1994; Carlsen and Grytten, 2000; Delattre and Dormont, 2003; Wilensky and Rossiter, 1983b), and many studies have not (Feldman and Sloan, 1988; Carlsen and Grytten, 1998; Hay and Leahy, 1982).

Part of the reason for the inconsistency of the results of SID studies is that it is not entirely clear what impact SID ought to have on the modeling of physician behavior or the equilibrium conditions. If demand inducement is expressed as a limited ability to shift the demand curve, then the demand curve still constrains price and quantity (albeit at a higher level of each), and the physician behaves just as before. If demand inducement is expressed as an unbounded ability to shift the demand curve, then price will always be infinity and so will quantity, unless inducement is costly. In the case of costly inducement, the physician is trading away the normal demand-curve constraint on price and quantity for an additional component in the cost function. This modeling would certainly be different, but it is not clear whether or how these differences would manifest themselves in ways observable by the econometrician.

Based on Evans' (1974) observation that physician incomes could be more stable than physician supply in a particular market, the most common tests for the existence of SID have analyzed physician response to an increase in the local supply of physicians (Peacock and Richardson, 2007; Delattre and Dormont, 2003; Carlsen and Grytten, 2000; Wilensky and Rossiter, 1983b; Richardson, 2001). It is reasoned that if the local supply of physicians (or physician services) increases, prices and profits would tend to fall. In order to combat this reduction in profit, physicians respond by inducing demand for services, so that patient treatment becomes more intensive. This increase in services per patient offsets the reduction in price so physician profits are at least in part preserved.

This approach is subject to criticism. Much of the criticism in the literature focuses on the ambiguous econometrics, such as the identification problem discussed by Auster and Oaxaca (1981) and dismissed by Peacock and Richardson (2007), who claim that including the quantity of physicians in the demand function does not cause an identification problem if the supply variable is quantity of services provided, not physician quantity. Phelps (1986) also pointed out the important difference between the supply of physicians and the supply of the physician-firm output. However, other criticisms exist.

One such criticism is that an increase in physician supply in a particular market is unlikely to be exogenous. Rather, it is likely that physician supply might increase in a particular market in response to profit opportunities. This presents a dilemma, however, because it requires that physicians are willing to increase their treatment intensity in response to falling prices, but unwilling to exploit pre-existing profit opportunities.

One potential explanation is that physicians in the local market are earning only a normal rate of return, so that when prices fall even marginally, they suffer losses which can be offset through demand inducement activities. This deepens the paradox, because a normal rate of return would be expected in a competitive market for physician services, but Stano (1985 and 1987) has pointed out that market power is a necessary pre-condition to the ability to induce demand. The so-called target income hypothesis (TIH) (Rizzo and Blumenthal, 1996) might be able to reconcile normal rates of return with market power, but as is implied above, a positive physician supply shock is unlikely to occur where rates of return are normal.

The only theoretical formulation that reconciles these difficulties is one that combines TIH with low-but-positive profit targets for physicians who have some market power. The positive profits are sufficient to explain entry; and TIH is sufficient to explain the physician response to that entry. Market power is necessary to explain how a physician's target level of profits could be positive. One implication of this theoretical formulation is that the market structure is monopolistically competitive—which is what Wong (1996) found—because of the existence of both market power and prices that fall in response to entry. TIH itself has been questioned on theoretical and empirical grounds, however (McGuire and Pauly, 1991).

The process of inducement in the standard approach to studying inducement is also not well-developed. Some important questions often remain unanswered, such as: How often can physicians increase visit intensity through inducement—every time there is an increase in physician supply, or only a finite number of times? If physicians can only induce demand only a finite number of times, in the long run all inducements will have taken place and it is not clear that the researcher should be able to identify instances of inducement. On the other hand, it is difficult to believe that inducement opportunities are infinite because there must exist some upper bound on visit intensity.

If within the relevant decision-making range there always exists unexploited possibilities for further inducement, demand inducement could become routine. A physician with an income target, for example, could reach that target by providing services to a mix of induced and un-induced demanders. For the researcher, separating routine inducement from strategic inducement would prove both theoretically and econometrically cumbersome.

One response to the question of whether inducement can be routine for a physician with a target income is to assume that inducement is costly: either monetarily (Stano, 1985 and 1987) or in terms of physician utility (Folmer and Westerhout, 2008). The cost or disutility element may untangle inducement from routine physician behavior, but it does not do so without raising other issues. For example, the standard model for researching SID is one in which physicians induce demand in response to increases in physician supply, but it is difficult to reconcile inducement that is too costly to be a routine part of physician practice with inducement that is a cost-effective solution to recovering revenues lost in the face of falling prices.

Models in which physicians suddenly shift to the otherwise-avoided practice of inducement in response to an exogenous increase in physician supply are not theoretically rigorous enough to be empirically useful. Even when they do find support for SID, Freebairn (2002) points out that these studies are faulty because the positive correlation between the physician-population ratio and the supply of services could reflect an availability problem. When the physician-population ratio increases, increased availability reduces the full price of medical services for patients, so that the quantity demanded rises.

Some researchers have attempted to overcome these difficulties by examining other market shifts that lead to more tractable results. Schaafsma (1994) points out that in the case of no SID, supply shifts will lead to similar estimates of demand elasticity regardless of the source of the shift, but under conditions of SID, the cause of the supply shift will impact the estimated demand elasticity. Stano (1987) discusses the role of competition in SID, pointing out that inducement will not be possible under highly competitive market conditions.

Another approach in the literature is to focus on the patient being induced to treatment. Given that a physician chooses to engage in a profit-maximizing level of demand inducement, the physician may discover that some patients are more subject to demand inducement than are others. This literature looks at medical care usage rates of patients by characteristics thought to be related to susceptibility to inducement. However, this approach leads to endogeneity problems because differences in medical care usage may be related either to differences in susceptibility to inducement or to the characteristics by which patients were separated. Researchers often lack the ability to observe variables correlated with susceptibility to inducement but uncorrelated with medical care demand.

Hay and Leahy (1982) show that medical professionals are at least as likely to utilize care as other patients. They argue that medical professionals are less likely to be susceptible to inducement; if physicians were inducing demand, they would target patients who were not medical professionals, so the pattern of medical care utilization ought to be reversed. Calcott (1999) points out that medically-informed patients may seek advice more often when symptoms (which they understand) are present. Poorly-informed patients may also underestimate the meaning of negative test results.

Other studies of SID have focused on physician responses to fee changes (Folmer and Westerhout, 2008; Feldman and Sloan, 1988; Melichar, 2009). Still others have used game-theoretic, search or bargaining frameworks to model SID (De Jaegher and Jegers, 2001; Dranove, 1988; Ellis and McGuire, 1990; Wolinksy, 1993; Rochaix, 1989).

3.3 ASSUMPTIONS OF THE PRESENT STUDY

The fact that SID is inherently difficult to discover empirically does not mean that it should be abandoned. There are responsible ways and important reasons to include SID in models of physician behavior. Inducing demand is possible for physicians because of the presence of third-party payers and asymmetric information. When employed correctly, it can improve profits. Whether the physician is modeled as a utility-maximizing individual or the owner of a profit-maximizing firm, the physician will appreciate higher income.

The model presented in Chapter 4 will assume that the physician's practice maximizes profits. A physician will be able to achieve higher levels of utility with more income, all else equal, as a rational utility-maximizer. Profit maximization is not inconsistent with utility maximization. Variables with different effects on utility and profit (such as time spent at work) are considered as part of a physician's prior decisions, such as choice of medical specialty and whether or not to induce demand. Stated differently, the physician modeled in Chapter 4 will attempt to maximize profit given an a priori choice about whether (and to what degree) to engage in SID. The decision about whether to engage in SID may change the structure of the physician's profit function, but not the physician's optimization problem, given that function.

The model presented in Chapter 4 will also assume that the physician's profit can be influenced by the amount of inducement activity undertaken by the physician. Rather than inducing patients to necessarily receive more or more intense care, as is done in many of the SID studies, the physician modeled in the next chapter will decide whether or not to establish a long-term relationship with a patient. Therefore, the possible "inducement" can be positive or negative; the physician induces the patient to accept a long-term relationship if it is profit-maximizing to do so and induces the patient to reject a long-term relationship if it is profit-maximizing to do so. In this way, the model presented in Chapter 4 avoids some of the issues of unobservable visit intensity and unobservable patient expectations.

The physician's inducement activity in the next chapter is subject to a three-fold constraint. First, as is assumed in many of the SID studies, Chapter 4 will assume that the inducement-related treatment in question is costly to provide. However, the model does not specify whether those costs are costs of inducement activity, or rather the usual costs of providing treatment to patients. In this way, the model of Chapter 4 avoids this issue. Second, because the “maintained” long-term relationship is the treatment subject to inducement, the model in the next chapter implies that inducement activity is limited to the finite sample of patients with whom the physician has an un-induced short-term relationship governed by the forces of supply and demand. The third constraint is a literal one: as discussed in Chapter 2, physicians treating patients for opioid dependence with buprenorphine are subject to caseload maximums set by federal law. Taken together, these three constraints allow the model in Chapter 4 to explain why physicians may engage in some, but not complete, inducement.

CHAPTER 4: THE MODEL

4.1 DESCRIPTION OF THE MODEL

The current study focuses on different approaches that a physician may take with patients. The categories considered in this study are "maintenance" patients—those patients successfully stabilized on buprenorphine and whom the physician has decided to maintain on buprenorphine—and "non-maintenance" patients. Non-maintenance patients can be patients in any of three possible phases of treatment (see Table 2.1): induction[3], stabilization or dose reduction. Therefore, some of a physician's non-maintenance patients will be those new patients still in the process of switching from a substance of abuse to buprenorphine (induction and stabilization). Other non-maintenance patients will be those the physician has decided to withdraw (or detoxify) and so are in the dose-reduction phase of treatment. After the patient has been successfully introduced to buprenorphine and stabilized, the physician can choose whether to keep the patient on buprenorphine indefinitely ("maintenance") or to taper the doses of buprenorphine until the patient is withdrawn from it as well.

It is assumed that demand for buprenorphine treatment is entirely patient-initiated and un-induced. This is justifiable for several reasons. First, only patients dependent on opioids are potential candidates for treatment, and it is unlikely that physicians will have much knowledge of a patient's opioid abuse except for when the patient is seeking treatment or if the patient is already in the physician's care. Also, the physicians in the sample are not all dedicated substance abuse specialists, so their ability to search for opioid dependent patients to induce into receiving treatment is limited. Finally, the decision to discontinue opioids must originate with the

[3] The reader should be careful to avoid confusing *inducement*, such as demand inducement (discussed in Chapter 3), with *induction*, which refers to the initial doses of buprenorphine that a patient receives after having just recently discontinued the substance of abuse.

abuser, although the environment of family, friends and criminal justice entities can exert pressure.

The model treats the decision regarding maintenance treatment as being entirely physician-determined and profit-focused. There may be un-induced exogenous patient demand for maintenance treatment, but the decision rests with the physician. In the model, if a patient does not want to be maintained on buprenorphine, the physician has the ability to induce (or coerce) the patient to receive it; if a patient wants maintenance treatment, the physician has the ability to deny it without losing the patient as a substance abuse treatment patient.

The physician in the model is a profit-maximizer who faces a downward-sloping demand curve for treatment of opioid dependence with buprenorphine. The physician chooses both what quantity of buprenorphine treatment (induction and stabilization) to supply to the market and what fraction of those patients successfully stabilized to induce to maintenance treatment. The first choice variable is constrained by the demand curve; the second choice variable is constrained between 0 and 1. In addition to the profit goal and the costs associated with buprenorphine treatment, maintenance treatment and inducement activities, the pair of choice variables together is constrained by a legally-imposed caseload maximum to which the physician is subject.

There are two time periods under consideration. In the first time period, the physician will take on new patients and treat them through the induction and stabilization phases of treatment, since patients must first be successfully stabilized before being maintained. In the second time period, the physician will again take on some new induction and stabilization patients, but may have also placed some fraction of the patients successfully stabilized on maintenance treatment.

The model makes some additional simplifying assumptions. The model assumes that stabilization is always successful. In reality, the physician has as potential maintenance patients only those patients who are successfully stabilized on buprenorphine. Of course, if there is an exogenous failure rate, then the model can be thought of as incorporating that failure rate into the physician’s choice for the fraction of patients to maintain, so the impact on the model should be minimal.

The model also assumes that there is no discount rate. Since it is only a two-period model, the discount rate would not have that great an impact anyway, especially when one considers that physicians, given the time spent in school and residency, are unlikely to be very myopic. If the model were extended to include additional periods (or infinite periods, which would be the most likely extension), a discount rate would be necessary. The absence of a discount rate would not significantly alter the results obtained from the model.

Finally, the model assumes that any patients who are withdrawn (or detoxified) are withdrawn within the first time period. Because it is only a two-period model, the “Maintenance then Withdrawal” treatment path from Table 2.1 is not possible. Induction and stabilization take at least one period of time in the present model. So any patients to be maintained will be maintained only in the second period. If those patients are to be later withdrawn, that would happen in a third period, which the model does not consider. In summary, in the first period of the model, all patients are *new patients*, experiencing induction to buprenorphine and stabilization. Some of those patients also experience dose reduction in that first time period; the rest return in the second time period as maintenance patients. In the second time period, the physician also begins again with another set of new patients.

4.2 THE ALGEBRAIC MODEL

The physician chooses to provide buprenorphine treatment to q new patients in each period. Demand for buprenorphine treatment is given by the inverse demand function $P = p(q)$ with $P_Q < 0$ and $P_{QQ} \geq 0$. Of those q patients treated in one period, the physician induces a fraction y of them to receive maintenance treatment in the next period, such that $0 \leq y \leq 1$. The price that the physician receives from maintenance is proportional to and less than the price of induction and stabilization treatment, because it is less intense. The variable r gives the ratio of the maintenance price to the induction and stabilization price, such that $0 < r < 1$.[4] The physician is constrained to a maximum total caseload of X patients, so that $X \geq (1 + y) \times q$.

Revenue in the first period will include revenue only from new patients, $q \times p(q)$. In the second time period, revenue again includes new patients but also includes revenue from induced maintenance treatment, $y \times q \times r \times p(q)$. Therefore:

$$TR = [q \times p(q)] + [q \times p(q)] + \left[(y \times q) + \left(r \times p(q)\right)\right]$$

$$TR = q(2 + ry)p(q) \tag{1}$$

Costs from both initial buprenorphine treatment and induced maintenance treatment contain fixed and increasing marginal components. The fixed components are c_0 and c_1 respectively. The variable component for initial induction and stabilization treatment is $\gamma(q)$. The cost of maintenance treatment is increasing in the number of maintained patients, $m = q \times y$, and is equal to $\psi(m)$ with $\psi_Q = y\psi_M$ and $\psi_Y = q\psi_M$, where ψ_M is the first derivative of ψ with respect to the total number of patients on maintenance. The cost of maintenance includes not just any material and labor costs (also included in the cost of induction and stabilization), but also any cost associated with establishing necessary relationships with providers of additional counseling

[4] For physicians paid under capitation, the prices would be equal and r would equal 1.

and other necessary follow-up treatment as well as any possible cost associated with inducing the patient to maintenance. If there exist costs from inducing patients away from maintenance (i.e., convincing patients that do not need it), then this would put downward pressure on ψ_M, but the model implicitly assumes that this effect is not great enough to make ψ_M or ψ_{MM} negative. The total cost function is:

$$TC = 2c_0 + c_1 + 2\gamma(q) + \psi(qy)$$

Combining the fixed cost components gives:

$$TC = C + 2\gamma(q) + \psi(qy) \tag{2}$$

Profit is total revenue minus total cost:

$$\pi = q(2 + ry)p(q) - C - 2\gamma(q) - \psi(qy) \tag{3}$$

The physician's problem is to maximize profit subject to the caseload constraint mentioned earlier.

$$\max_{q,y} q(2 + ry)p(q) - C - 2\gamma(q) - \psi(qy)$$

$$\text{s.t.}\, X - q - qy \geq 0 \tag{4}$$

The Lagrangian is:

$$\mathcal{L}\{q, y, \lambda\} = q(2 + ry)p(q) - C - 2\gamma(q) - \psi(qy) + \lambda(X - q - qy) \tag{5}$$

The first order conditions are:

$$\frac{\delta\mathcal{L}}{\delta q} = 2p + 2qP_Q + pry + qryP_Q - 2\gamma_Q - y\psi_M - \lambda(1 + y) \leq 0 \tag{6}$$

$$\frac{\delta\mathcal{L}}{\delta y} = pqr - q\psi_M - \lambda q \leq 0 \tag{7}$$

$$\frac{\delta\mathcal{L}}{\delta \lambda} = X - q - qy \geq 0 \tag{8}$$

4.3 KUHN-TUCKER CONDITIONS

Because of the inequality constraint, it is appropriate to use Kuhn-Tucker (KT) conditions (Kuhn & Tucker, 1951) to determine the possible solutions for *q* and *y*. The Kuhn-Tucker conditions are:

$$q \times \left(\frac{\delta \mathcal{L}}{\delta q}\right) = 0 \tag{9}$$

$$y \times \left(\frac{\delta \mathcal{L}}{\delta y}\right) = 0 \tag{10}$$

$$\lambda \times \left(\frac{\delta \mathcal{L}}{\delta \lambda}\right) = 0 \tag{11}$$

The KT conditions, combined with the definitions of *q* and *y*, give rise to eight total possibilities for solutions for *q*, *y* and the impact of the caseload maximum *X*, which are summarized in the table below. If $\lambda \neq 0$, equations (11) and (8) imply that the caseload maximum is binding.

TABLE 4.1 – The eight possibilities based on the Kuhn-Tucker conditions

Possibility	Constraint on q	Constraint on y	Caseload maximum
1	$q \geq 0$	$0 \leq y \leq 1$	$X \geq q(1 + y)$
2	$q \geq 0$	$0 \leq y \leq 1$	$X = q(1 + y)$
3	$q \geq 0$	$y = 0$	$X \geq q(1 + y)$
4	$q \geq 0$	$y = 0$	$X = q(1 + y)$
5	$q = 0$	$0 \leq y \leq 1$	$X \geq q(1 + y)$
6	$q = 0$	$0 \leq y \leq 1$	$X = q(1 + y)$
7	$q = 0$	$y = 0$	$X \geq q(1 + y)$
8	$q = 0$	$y = 0$	$X = q(1 + y)$

Possibilities #5 – #8 all involve a solution of 0 for *q*. If the physician chooses to treat 0 patients for opioid dependence then, regardless of the choice of *y*, the physician will also maintain 0 patients. This solution is uninteresting.

Possibilities #3 and #4 from Table 4.1 allow for non-zero solutions for q but force solutions of 0 for y. This means that the physician chooses only to treat patients for induction and stabilization and then immediately initiates does reduction, never placing patients on a maintenance regimen. This is an interesting subset of physician solutions to the problem, but in the case of Possibility #4, it is not also mathematically interesting. In Possibility #4, the caseload maximum binds. This means that the physician chooses to treat the maximum number of patients and never maintains any; $q = X$. This will not lead to any testable hypotheses. Possibility #3, however, will. In this case, the physician chooses not to maintain any patients but also has excess caseload capacity. Specific solutions are discussed in the next section.

In Possibilities #1 and #2 from Table 4.1, the solution can involve nonzero solutions for both q and y, which makes them empirically interesting. These possibilities are additionally interesting when viewed in light of ongoing philosophical differences within the substance abuse treatment community. Some believe strongly in long-term medical maintenance in the treatment of opioid dependence, while others believe strongly that the goal for the substance-abusing patient ought to be complete independence from narcotics, including medications like buprenorphine. If these positions hold strongly enough, then even given profit considerations, it should be expected that physicians of the first type will choose $y = 1$ and eventually have an entire caseload of only patients on maintenance and physicians of the second type will choose $y = 0$ and never keep any patients on maintenance. Possibilities #1 and #2 concern physicians who choose a mixture of the two approaches. If strict ideology is not driving a physician's choice of treatment style, then one challenge to the assumption of profit-maximization behavior among physicians is weakened.

In summary, of the eight possible outcomes implied by the KT conditions necessary to solve the physician's profit-maximization problem subject to an inequality constraint, this study will explore only the first three given in Table 4.1.

4.4 RESULTS

The results implied by the first three possibilities from Table 4.1 are explored in the three subsections that follow. Each possibility yields results that apply to a specific subset of physicians or observations in the data. The data and the subsample creation are covered in the next two chapters.

4.4.1 POSSIBILITY ONE

Possibility #1 has non-zero solutions to *q* and *y* with a caseload that does not bind ($\lambda = 0$). This means that equations (6) and (7) above are satisfied with equality to zero.

$$2p + 2qP_Q + pry + qryP_Q - 2\gamma_Q - y\psi_M = 0 \tag{12}$$

$$pqr - q\psi_M = 0 \tag{13}$$

Equation (13) can be solved for ψ_M and substituted into (12), which eliminates two terms:

$$2p + 2qP_Q + qryP_Q - 2\gamma_Q = 0 \tag{14}$$

Because the caseload maximum is not binding, there is no other equation that can be used to find exact solutions for *q* and *y*. General solutions can be achieved from (14):

$$q^* = \frac{2(\gamma_Q - p)}{(2+ry)P_Q} \qquad \text{and} \qquad y^* = \frac{2(\gamma_Q - p - qP_Q)}{qrP_Q} \tag{15}$$

The number of patients on maintenance treatment in period 2 (*m*) is equal to the product of the number of patients stabilized in the first period (*q*) and the proportion of those patients induced to maintenance (*y*): $m = q \times y$. Using the results in (15), it can be seen that:

$$m^* = \frac{2(\gamma_Q - p - qP_Q)}{rP_Q} \tag{16}$$

This solution for *m* can be evaluated for comparative statics results. The following can be confirmed[5]:

$$\frac{\partial m^*}{\partial r} < 0 \qquad \frac{\partial m^*}{\partial \gamma_Q} < 0 \qquad \frac{\partial m^*}{\partial E_D} < 0 \tag{17}$$

where E_D is the price elasticity of the demand for treatment of opioid dependence.

The first of these comparative statics results at first appears surprising, because it implies that the greater the ratio of the price of maintenance to the price of induction and stabilization, the fewer patients the physician would choose to place on maintenance. The key to understanding this result is to recall that the caseload maximum does not bind in this case. The physician intentionally chooses to treat fewer total patients than allowable. The marginal cost of another patient on maintenance is always equal to the marginal revenue from another patient on maintenance. Equation (13) shows that $\psi_M = pr$, and this condition eliminates most of the impact of *r* on the first order conditions for *q*, except for the term $qryP_Q$ in (14). This term represents the decrease in maintenance revenue that results from a one-unit increase in *q*, due to the fact that an increase in *q* pushes down *p*. In other words, the greater is the value of *r*, the greater is the rate at which the marginal revenue of maintenance falls as the number of patients treated increases. A high *r* magnifies the negative price effect of an increase in the number of patients treated, causing the physician to choose a lower value for *q* (new patients), which reduces *m* (patients maintained).

[5] The elasticity of demand (E_D) for withdrawal treatment in this model is equal to $p / (qP_Q)$. Holding *q* constant, the derivative of m with respect to E_D is equal to the derivative of *m* with respect to p / P_Q.

An increase in the marginal cost of induction and stabilization γ_Q decreases the optimal choice for the number of new patients q^*, holding the choice for y constant, as should be expected. All else equal, this will drive down the optimal solution for m.

Physicians with more market power face demand curves that are overall less price elastic, which means that the value of the price elasticity of demand is higher, because it is less negative. Therefore, the third inequality in (17) can be interpreted as saying that the derivative of m^* with respect to market power is negative; physicians with more market power will maintain fewer patients, and physicians with less market power will maintain more patients.

The specific hypotheses based on these results are discussed in Section 4.5.

4.4.2 POSSIBILITY TWO

Possibility #2 allows for nonzero solutions for both q and y but, unlike in Possibility #1, with a binding caseload maximum. The fact that the caseload maximum binds means that the equation $X = q(1 + y)$ can be added to equations (12) and (13) above and exact solutions for q and y and m can be found.

$$q^* = \frac{2\gamma_Q + pr - 2p - rXP_Q - \psi_M}{P_Q(2-r)} \qquad y^* = \frac{2\gamma_Q + pr - 2p - \psi_M - 2P_Q X}{rXP_Q - 2\gamma_Q - pr + 2p + \psi_M}$$

$$m^* = \frac{2\gamma_Q + pr - 2p - \psi_M - 2P_Q X}{P_Q(r-2)} \tag{18}$$

These three solutions can be evaluated for the impact of a change in the caseload maximum, X:

$$\frac{\partial q^*}{\partial X} = \frac{-r}{(2-r)} < 0 \qquad \frac{\partial y^*}{\partial X} = \frac{1}{q}\left(1 + \frac{r(1+y)}{(2-r)}\right) > 0 \qquad \frac{\partial m^*}{\partial X} = \frac{2}{(2-r)} > 0 \tag{19}$$

This means that the physician bound by the current caseload maximum would respond to an increase in that caseload maximum by treating fewer new patients and keeping more patients on maintenance.

At first glance, the reason for this may not seem obvious. One might expect that profit-maximization should make the physician indifferent between an additional new patient or an additional maintenance patient, but the results in (19) contradict this intuition. A hypothetical example clarifies this result. Suppose a physician currently chooses to treat a certain number of opioid dependent patients and to maintain a certain number of those patients, such that the sum of the numbers of patients equals the caseload maximum, and the physician would rather have treated more patients total had the physician not faced the caseload maximum. If the caseload maximum is increased by 1, the physician can choose either to treat one more new patient or to maintain a long-term relationship with one additional current patient. Under what conditions will a physician choose an additional new or an additional maintenance patient?

Keeping one more patient on maintenance will increase the physician's costs by ψ_M. Keeping one more patient on maintenance will increase the physician's revenue by pr. So the marginal profit of an additional maintenance patient is $pr - \psi_M$.

If the physician were to fill the hypothetical 1-patient increase in the caseload maximum by treating a new patient (increasing q), then the costs would rise by γ_Q. The revenue change caused by this increase in q has three components. The output effect on revenue of an increase in q is p. The price effect on revenue of an increase in q is qP_Q. This price effect of the increase in q also applies to the price of maintenance. The price effect in that case is $qryP_Q$. Therefore the change in revenue from treating one additional new patient is $p + qP_Q + qryP_Q$.

The physician will prefer adding another maintenance patient to adding another new patient so long as:

$$pr - \psi_M > p + qP_Q + qryP_Q - \gamma_Q \qquad (20)$$

The third term on the right-hand side of (20) represents the price effect of an increase in initial induction and stabilization patients on the revenue earned from maintenance patients, referred to from here on as the "cross-price effect." The only way that the physician could prefer to choose another new patient would be if the new-patient-specific difference between marginal revenue and marginal cost was sufficiently greater than the difference between marginal revenue and marginal cost for maintenance—i.e., large enough to make up for the cross-price effect. However, had this been the case, the physician's pre-caseload-increase mix of maintenance and non-maintenance patients would have been inefficient, because treating more new patients, and maintaining fewer of them, would have yielded higher profits.

A profit-maximizing physician for whom another new patient is marginally more profitable—net of the negative cross-price effect—than another maintenance patient is not feasible within the model. A reduction in the number of maintenance patients and an increase in the number of new patients would have reduced the negative cross-price effect of an increase in new patients, so further increases in non-maintenance patient counts (and reductions in maintenance patient counts) would likewise have been profitable.

Stated differently, it is possible for the physician to respond to an increase in the caseload maximum by deciding to keep one additional patient on maintenance rather than to treat another new patient to avoid the negative cross-price effect, but it is not possible for a physician to respond to an increase in the caseload maximum with a willingness to bear the negative cross-price effect of treating an additional new patient, because the tradeoff would have been even more attractive prior to the caseload maximum increase, when treating one additional new patient would have required reducing the number of patients on maintenance, thereby reducing the negative cross-price effect.

Another, simpler way, to interpret this result is to say that the caseload maximum, when it binds and the physician treats both maintenance and non-maintenance patients, necessarily binds on maintenance patients. Equation (7) can be used to confirm this result. Possibility #2 from Table 4.1 constrains all of the first order conditions to be equal to zero. This causes λ^* to take on the value $pr - \psi_M$. The usual interpretation of λ^* is that it represents the impact of a change in the constraint on the value of the state variable, in this case profit. The expression $pr - \psi_M$ is the difference between the marginal revenue and marginal cost of an additional maintenance patient, implying that a 1-unit change in the caseload maximum X leads *only* to a 1-unit change in the number of patients on maintenance.

4.4.3 POSSIBILITY THREE

The third possibility that will be explored is the possibility that the physician chooses a positive number of patients for induction and stabilization, but chooses not to maintain them, while not reaching the caseload maximum: Possibility #3 from Table 4.1. Equation (6) from above holds with equality to zero, and is simplified when y and λ are set to zero.

$$\frac{\delta \mathcal{L}}{\delta q} = 2p + 2qP_Q - 2\gamma_Q = 0 \tag{21}$$

Equation (21) can be solved to find the profit-maximizing value for q, the number of patients treated:

$$q^* = \frac{p-\gamma_Q}{-P_Q} \tag{22}$$

The only reason for y^* to be equal to zero in the absence of a binding caseload would be if the marginal cost of maintenance was always greater than the marginal revenue of maintenance. This result, that $pr \leq \psi_M$, can also be obtained if equation (7) is evaluated under this set of KT conditions.

Using the same definition of the price elasticity of demand for treatment of opioid dependence from section 4.4.1 above, the following comparative statics are achieved:

$$\frac{\partial q^*}{\partial \gamma_Q} < 0 \qquad \text{and} \qquad \frac{\partial q^*}{\partial E_D} < 0 \tag{23}$$

Again, the second result can be read as saying that the derivative of q^* with respect to "market power" is negative. Physicians with more market power with treat fewer patients; physicians with less market power will treat more. The specific hypotheses based on these results are discussed in the next section.

4.5 HYPOTHESES

The three possibilities discussed in Section 4.4 lead to three distinct empirical experiments carried out in subsequent chapters. This section will summarize the hypotheses generated by the quantitative results of the model.

4.5.1 EXPERIMENT ONE – MAINTENANCE PATIENTS

Based on the results derived in Section 4.4.1, the first experiment will focus on physicians who choose positive values for both q and y, demonstrated by a positive number of maintenance and non-maintenance patients, but who do not reach the maximum-allowable caseload. The dependent variable in Experiment #1 will be the total number of patients currently being maintained, $m^* = q^* \times y^*$.

It was shown in Section 4.4.1 that the total number of patients on maintenance was negatively related to r (the ratio of the price of maintenance to the price of induction and stabilization), γ_Q (the marginal cost of induction and stabilization treatment), and the price elasticity of demand for treatment of opioid dependence.

There are several variables available in the data that are related to these three parameters. Physician specialty can be related to all three. Regarding specialty, the following hypotheses are advanced:

- Specialties with low market power (facing lower, i.e., more negative, demand elasticity), such as internal medicine, family medicine or pediatrics, ought to have more patients on maintenance, relative to other specialties, all else equal.
- Physicians specializing in psychiatry, a specialty wherein the physician is able to capture more maintenance revenue through psychotherapy follow-up (*r* is higher), ought to maintain fewer patients, relative to other specialties, all else equal.
- Physicians who are certified addiction treatment specialists (or in general treat more patients for addiction) and who therefore face lower marginal costs for providing induction and stabilization treatment (both psychic and otherwise), ought to have more patients on maintenance, relative to physicians lacking addiction certification, all else equal.

Practice setting can also impact these parameters.

- Physicians who practice in settings where there are other physicians may bear higher marginal costs of induction and stabilization, due to a negative response of the other physicians in the practice to the prospect of having opioid dependent patients frequenting the premises. Physicians in single specialty group practices or who practice in their own solo setting ought to maintain more patients, relative to physicians in other settings, all else equal.
- Physicians who practice in hospitals, however, due to the increased availability of support from other types of staff (like security), may also face low marginal costs

for treatment of opioid dependence, and ought to maintain more patients, relative to physicians in other settings, all else equal.

- Physicians who are part of an HMO are more likely to be paid based on capitation, which would increase the value of r to 1; these physicians ought to maintain fewer patients, relative to non-HMO patients, all else equal.

Additionally:

- Physicians with more experience will face lower marginal costs of induction and stabilization treatment and therefore ought to maintain more patients, relative to less experienced physicians, all else equal.

The variable X, the caseload maximum, does not appear in the comparative statics results, but the maximum caseload increase in reality is a large one—from 30 to 100. It is therefore also hypothesized that physicians subject to the higher caseload maximum will maintain more patients, all else equal. A marginal increase in the caseload maximum should have no impact on the number of patients maintained, because the physicians in this case are not bound by the maximum. However, this increase is not a marginal one and a physician not bound at 100 can certainly treat more patients than a physician not bound at 30.

4.5.2 EXPERIMENT TWO – RESPONSE TO CASELOAD LIMIT INCREASE

Possibility #2 discussed in Section 4.4.2 concerned physicians who treat positive numbers of maintenance and non-maintenance patients and who are bound by the caseload maximum. The primary result from the model in this case was that an increase in the caseload maximum ought to increase the number of patients on maintenance and decrease the number of non-maintenance patients, all else equal.

It can be seen from looking at the derivative of m* with respect to X in equation (19) that the greater the value of the ratio of the price of maintenance to the price of induction and stabilization, r, the greater the positive impact of an increase in the caseload maximum on the number of patients on maintenance. Physicians who face a higher r (psychiatrists or physicians in HMOs) will have a stronger tendency to maintain more patients after an increase in X, relative to other patients, all else equal.

It is also hypothesized that the effects of an increase in the caseload maximum on the numbers of patients induced, stabilized, and maintained will be even stronger for physicians whose behavior is most likely to conform to the model of the profit-maximizing physician presented here, specifically non-addition-specializing physicians whose treatment decisions are less likely guided by ideology and more likely guided by profit maximization, as suggested in the model.

4.5.3 EXPERIMENT THREE – NON-MAINTENANCE PATIENTS

Possibility #3, discussed in Section 4.4.3 dealt with physicians who maintain no patients, while not bound by the caseload maximum. It is possible that physicians who choose not to maintain patients do so because they are ideologically anti-maintenance. However, these physicians are not bound by the caseload maximum—that is, they treat fewer patients than they are legally allowed to treat. This makes a strict anti-maintenance and pro-withdrawal ideology less likely, though not impossible.

The equations in (22) show that these physicians will treat fewer patients when the marginal cost of induction and stabilization treatment is higher and when the physician’s market power is greater. Connecting these results to variables available in the data provides the following testable hypotheses:

- Physicians in specialties of the primary-care type (internal medicine, family medicine, pediatrics) will treat more patients, relative to physicians in other specialties, all else equal, because they have less market power and the opportunity cost of treating a substance-abusing patient is lower.
- Physicians in practice settings where costs of treatment are lower (solo practices, single-specialty group practices or hospitals) will treat more patients, relative to physicians in other practice settings, all else equal.
- Physicians who are certified addiction specialists or who have significant experience in addiction treatment will face lower marginal costs for induction and stabilization and will therefore choose to treat more patients, relative to non-addiction specialists, all else equal.

It is also further hypothesized that physicians subject to the higher 100-patient caseload maximum will report having more non-maintenance patients than do physicians subject to the lower 30-patient caseload maximum. The reasoning for this is the same as the reasoning discussed in Section 4.5.1: a marginal change in X should not be expected to have any impact, but a change from 30 to 100 cannot be considered marginal.

CHAPTER 5: THE SURVEY DATA

5.1 THE PHYSICIAN SURVEY

As part of the FDA approval process for Subutex and Suboxone, Reckitt Benckiser Pharmaceutical is required to conduct research to track diversion and abuse. The research includes a quarterly survey of a random sample physicians certified to prescribe buprenorphine to opioid dependent patients (herein referred to as the “Physician Survey”). Physicians are compensated $100 for the time (about 15 – 20 minutes) that it takes to fill out the survey.

The Physician Survey has undergone changes since its first waves. Initially, the random sample of physicians was drawn from the publicly-available CSAT list of physicians certified to treat using buprenorphine, inclusion on which was voluntary. Starting in 2005, the sample was drawn instead from the DEA’s list of all certified physicians, regardless of whether they had opted to have their name listed on the public CSAT website.

Because the sample for each wave is a random sample from either the CSAT list or the DEA list, many physicians appear in the data multiple times. The original complete sample has 10,873 observations over 29 survey waves from 6,739 unique physicians, with each physician appearing an average of 1.6 times. The earliest survey responses were recorded in November of 2003; the most recent responses were recorded in October of 2010.

Most of the questions have remained unchanged in various iterations of the survey, though some have changed slightly. Likewise, certain waves of the survey included additional marketing questions of interest to Reckitt Benckiser but not necessary for FDA surveillance.

Access to most of the variables of the data was provided by CRS Associates, LLC, who manages the survey. Salvatore di Menza and Dr. Cynthia Arfken were instrumental in securing access and providing data. In Section 5.2, the variables used in the study are discussed. The next section briefly discusses some of the limitations encountered in the survey data. The last section briefly discusses an additional source of data used in the study.

5.2 AVAILABLE VARIABLES

The empirical models for Chapters 6 and 7 make use of the following variables from the Physician Survey. Appendix A gives the full text of the relevant questions from the Physician Survey.

- Physician Specialty – respondent chooses up to 3 primary specialties from a list of 23 choices.
- Years Licensed to Practice Medicine – respondent indicates the whole number of years for which he or she has been practicing medicine.
- Addiction Certification – respondent can indicate that he or she holds any of three possible addiction certifications, or can indicate that he or she holds no certification in addiction medicine.
- Practice Setting – respondent chooses one of eight choices that best describes the setting in which he or she primarily practices.
- Time Certified – respondent indicates the length of time for which he or she has been certified to treat patients with buprenorphine by choosing the range into which it falls.
- Today's Date – respondent indicates the date on which the survey was completed.
- Percent of Practice Substance-Abusing – the respondent indicates the percentage of his or her time is spent treating substance abusing patients by choosing the range into which it falls.

- Total Current Buprenorphine Patients – depending on the survey wave, the respondent indicates the total number of patients currently on buprenorphine by indicating how many are on different formulations or brand names of buprenorphine.
- Patients in Phases of Treatment – respondent, in some waves, indicates the number of patients on a “withdrawal regimen” or a “maintenance regimen”; in other waves, the respondent indicates the number of patients in phases “induction,” “maintenance,” and “dose reduction.”
- Patients Turned Down – respondent indicates the number of patients that he or she has had to turn down for treatment in the last 90 days because of the federal patient caseload maximum.

In addition to these variables from the Survey instrument, the data set used also included coded physician IDs so multiple observations can be linked by respondent, the respondent’s state of residence, and the first three digits of the respondent’s zip code.

5.3 SURVEY DATA LIMITATIONS

The most important limitation of the data from the point of view of testing the hypotheses generated by the algebraic model is that it does not record variables that correspond exactly to the model. One of the model’s two choice variables is *y*, the fraction of successfully-stabilized patients to place on maintenance treatment. The survey does not ask physicians what percentage of their patients are eventually placed on maintenance, but rather the total number on maintenance at the time that the survey is completed. In the simple specification of the model, these are easily disentangled because it is only a two-period model. The physicians surveyed have, in most cases, been prescribing buprenorphine for multiple periods, so that observed patient counts do not fully reveal y. Regardless of the actual rate at which a physician places patients on maintenance, over time, the fraction of the caseload dedicated to maintenance patients should converge to 1 if y is positive.

Fortunately, the results of the optimization problem provide results that can be evaluated with respect to m, or $q \times y$, the total number of patients on maintenance. Further experimentation based on this model might be hampered by the inability to accurately calculate the fraction of patients placed on maintenance.

Another very important limitation of the data is that it does not directly indicate, for each observation, the caseload maximum that the physician faced at the time that the survey was completed. Because the caseload maximum is particularly important to Experiment 2 this is a significant limitation. The caseload maximum is also important to the other experiments where, for example, unconstrained physicians who face a higher constraint will have higher patient counts than unconstrained physicians who face lower constraints.

The final limitation of the data is one that is common to all survey data, and that is that it is subject to respondent error. There are, for example, cases where the same physician reports in different waves inconsistent answers for number of years practicing medicine—for example, reporting *fewer* years practicing medicine in a *later* survey wave. This and other related issues are covered in the next chapter.

5.4 SUPPLEMENTAL DEA LISTS

Through CRS Associates, LLC, access was provided to DEA lists of the physicians who have filed secondary notification of their intent to treat up to 100 patients. Because certification must be renewed every three years, this data provide only the caseload maximum that the physician will face at the time of the expiration of their current certification. In other words, a date associated with a caseload limit of 100 in this data serves as an upper bound of the date on which the physician filed the necessary second notification of the intent to treat up to 100 patients. This data will be used in Chapter 6 not to identify those physicians who face a caseload maximum of 100, but rather to identify those who certainly do not face a caseload maximum of 100 because they fail to ever appear on this list with a caseload maximum of 100.

CHAPTER 6: METHODS

6.1 SUBSAMPLE CREATION

The three experiments introduced in Section 4.3 all require unique subsamples of physicians, based on the KT conditions that gave rise to them. Those three subsamples were created from the same original sample, created as described below.

Originally, the 30-patient limit on physicians prescribing buprenorphine applied to the total number of patients treated in the entire group. Therefore, large health care systems were limited to treating 30 patients. This limit was amended in August 2005. In order to eliminate any observations from physicians that may have faced this “group” limit, all of the observations from waves 1 through 8 of the survey were deleted.

Where missing, states were manually filled in based on the first three digits of the zip codes, as reported in the data, but one observation was deleted for possessing neither piece of data. All observations with 0 or more than 4 reported “primary specialties” were deleted. There were only 4 observations of this type.

The following process was used to determine the practice setting for observations that failed to report a practice setting. The 102 observations for which practice setting was blank and the physician did not appear elsewhere in the data were all deleted, because there would be no basis for imputing the practice setting. For the rest of the observations with missing practice settings, the associated physicians all appeared at least one other time in the data where practice setting was indicated. If the physician ever reported “OTP” (“other type of practice”) as the practice setting, then OTP was coded for all missing observations. Otherwise, the treatment setting for the wave closest in wave number to the wave with the missing practice setting was used as the treatment setting. All observations with practice setting indicated as “OTP” were deleted.

Several steps were taken to identify the caseload maximum faced by the physician at the time of observation, an imputed variable labeled *X_limit*. First, for any physician not ever appearing with a caseload of 100 on the supplemental list from the DEA, all observations were coded as *X_limit* = 30. All observations that occurred prior to December 29, 2006 were coded as *X_limit* = 30 because this is the date on which the amendment to DATA 2000 allowing physicians to treat up to 100 patients went into effect.

Physician responses to the survey question about the length of time for which the physician has been certified to prescribe buprenorphine (less than a year, 1 – 2 years, 3 – 4 years, more than 4 years) were also used. Combining these question responses with the date of the response, earliest and latest possible certification dates were calculated for each observation. Then, these earliest and latest possible certification dates were averaged for each physician. If the date on which an observation occurred exceeded the latest possible certification date by one year or more, the observation was coded as *X_limit* = 100—since the requirements for the caseload maximum of 100 require that the physician has been certified to prescribe buprenorphine for one year—unless the observation had already been coded as *X_limit* = 30. If the date on which an observation occurred was within one year of the earliest possible certification date, the observation was coded as *X_limit* = 30.

After all of the preceding coding was done, any observations for which the date of observation is more than one year greater than another observation for the same physician were coded as *X_limit* = 100, unless the observation was already coded as *X_limit* = 30. Any observations for which *X_limit* could not be imputed were deleted.

Experiment #1 relates to those physicians who treat positive numbers of maintenance and non-maintenance patients. In the algebraic model, “non-maintenance” could only mean new patients; in reality, non-maintenance patients can also include patients that are in the process of having doses of buprenorphine reduced to withdrawal, whether or not those patients were ever on maintenance. The data is easily filtered for these two criteria. However, the KT conditions related to Experiment #1 indicate that the caseload maximum does not necessarily bind, so the subsample creation for Experiment #1 also requires determining which observations are consistent with a non-binding constraint.

First, the numbers of patients on Subutex and on Suboxone were summed to determine the relevant total number of current buprenorphine patients. In order to determine whether the caseload was binding, this total was compared to the imputed value for the caseload maximum faced at the time of observation (the variable *X_limit* discussed above). Physicians were eliminated if the total number of current buprenorphine patients was equal to or exceeded this imputed limit.

Further, observations wherein physicians reported turning away patients in the previous 90 days due to the caseload maximum were also eliminated. There are two reasons for this. First, a physician might face exogenous shocks to patient numbers (if a patient moves or is jailed, for example) that could cause fluctuations in the number of patients receiving care that do not necessarily reflect the physician’s choices. If a physician usually treats exactly 100 patients, but happens to be at a total of only 97 at the time the survey is completed, this physician ought to be considered to be bound by the caseload maximum. Secondly, a caseload maximum can begin to alter physician behavior even before it is reached. A physician with a 97-patient caseload is aware of how close she is to the caseload maximum, and that caseload maximum may bind even if $q + m < 100$. The final sample size for Experiment #1 was 2,079 observations.

The construction of the subsample for Experiment #2 was the most complicated. Because the results discussed in 4.5.3 concern how a caseload-constrained physician would respond to a change in caseload, the appropriate subsample includes observations where the physician:

- faces a caseload maximum of only 30 patients,
- reports positive numbers of both maintenance and non-maintenance patients,
- appears to be bound by the caseload maximum of 30 patients, and
- appears later in the data facing a higher (100-patient) caseload maximum.

In order to accomplish this, the imputed caseload maximum faced at the time of observation (the variable *X_limit* discussed above) was used to separate observations by the caseload maximum faced at the time of observation. First, the observations for which the imputed caseload maximum was equal to 30 were evaluated. Any of these observations where either the number of maintenance patients or the number of non-maintenance patients was equal to zero were deleted. Of these observations, only the observations where either the sum of the number of maintenance and the number of non-maintenance patients was equal to 30 or the physician reported having turned down patients in the previous 90 days were retained. The rest were deleted.

Given the selection of the appropriate 30-patient-limit observations just described, the data was further evaluated. Only physicians still appearing at least twice, with at least one observation at each caseload limit, were retained. All observations associated with other physicians were deleted. This led to the intermediate set of observations from the original data on which the subsample for Experiment #2 was based. All possible pairings of a physician's multiple observations were evaluated, and those that paired one observation with a caseload maximum of 30 with one observation with a caseload maximum of 100 were retained. From there, any pairs where the physician practice setting or physician specialty choices differed between the two observations were eliminated. At this point, the final sample size of observations for Experiment #2 (the number of "pairs" meeting the above criteria) was 80, due to the many restrictions on the definition of the sample. For 75 of the 80 observation pairs, the first observation occurred in 2006; for the other five, the first observation occurred in 2008 or 2009. These five observations were eliminated, so that the final sample size was 75.

Experiment #3, related to the third possibility derived from the KT conditions from Table 4.1, considers observations wherein the physician chooses not to maintain any patients, while not reaching the caseload maximum. The creation of this subsample is straightforward. Any observations for which the number of patients on maintenance was non-zero were deleted. Then, the imputed caseload maximum (the variable *X_limit* discussed above) was used to eliminate any observations for which the total number of patients being treated was equal to the caseload maximum of 30 or 100. Finally, any observations for which the physician reported having turned patients away in the previous 90 days due to the caseload maximum were eliminated, even if the number of patients treated was not exactly equal to the caseload maximum. The reasoning for this is discussed above in the description of the Experiment #1 subsample. The final sample size of observations for Experiment #3 was 259.

6.2 VARIABLE CREATION

The states indicated by the respondent—or coded based on the first three digits of the zip code—were used to create "region" dummy variables based on the U.S. Census Bureau's definition of the regions of the U.S., as follows[6]: *Region_NE* includes Maine, New Hampshire, Vermont, Massachusetts, Rhode Island, Connecticut, New York, New Jersey, and Pennsylvania; *Region_MW* includes Ohio, Indiana, Illinois, Michigan, Wisconsin, Minnesota, Iowa, Missouri, North Dakota, South Dakota, Nebraska, and Kansas; *Region_S* includes Delaware, Maryland, District of Columbia, Virginia, West Virginia, North Carolina, South Carolina, Georgia, Florida, Kentucky, Tennessee, Alabama, Mississippi, Arkansas, Louisiana, Oklahoma, and Texas; *Region_W* includes Montana, Idaho, Wyoming, Colorado, New Mexico, Arizona, Utah, Nevada, Washington, Oregon, and California; *Region_Pac* includes Hawaii, Alaska and Guam; *Region_Car* includes the Virgin Islands and Puerto Rico. In all of the regression models, the last two region dummies were not included, so they can be thought of as one excluded "*Region_Other*" variable.

Physicians who claimed to have primary specialties in internal medicine, family medicine or pediatrics were combined, and a dummy variable *Sp_PCPtype* was created and coded equal to 1 for these physicians, because of the similarities of these physicians in terms of patient relationships and market power.

A variable called *Add_Cert* was created to indicate if the physician at the time of observation held a board certification in addiction medicine (1) or held no such certification (0). In the survey, the physician is directed to "mark any of these certifications in addiction medicine" currently held: American Board of Medical Specialties, American Society of Addiction Medicine, American Osteopathic Association, or "Not certified in addiction medicine." If a physician chose any of the first three options, without choosing the fourth, that observation was coded as *Add_Cert* = 1. If the physician chose the fourth option either by itself

[6] The Census Bureau includes Hawaii and Alaska in the West Region and does not include Guam, Puerto Rico or the Virgin Islands.

or with the first or third option, that observation was coded as *Add_Cert* = 0. It is possible that the physician misread the question and only responded positively to American Board of Medical Specialties or American Osteopathic Association because of other *non*-addiction-medicine certifications held. If a physician responded positively to holding a board certification from the American Society of Addiction Medicine, the observation was coded as *Add_Cert* = 1, regardless of whether the fourth choice was also chosen.

TABLE 6.1 – Average Date of Survey Completion by Wave

Wave	Average Date of Survey Completion
9	January 10, 2006
10	April 17, 2006
11	July 10, 2006
12	October 8, 2006
13	January 7, 2007
14	April 12, 2007
15	July 20, 2007
16	October 12, 2007
17	January 18, 2008
18	April 18, 2008
19	July 13, 2008
20	October 13, 2008
21	January 10, 2009
22	April 11, 2009
23	July 9, 2009
24	October 11, 2009
25	January 11, 2010
26	April 9, 2010
27	July 12, 2010
28	October 10, 2010

For observations where the date of the response to the survey was missing, the average date for responses from the same wave was entered. The dates of responses were converted to serial numbers and then averaged. The average response dates for the survey waves are given in Table 6.1.

Because there were a number of inconsistencies with respect to the amount of time for which the physician has been practicing medicine, for each observation, the number of years practicing was subtracted from the date of the observation to calculate an implied date that the physician started practicing medicine (as if the true answer was the integer as reported). Then, these implied start dates were converted to a serial number and averaged for each physician. Then, the date of the response was compared to this average implied start date for medical practice to construct the variable *Yrs_Practicing*.

Some variables were created specifically for Experiment #2. Because Experiment #2 requires looking at changes in the numbers of maintenance and non-maintenance patients given a change in caseload maximum, differences in these patient counts were calculated for all possible iso-physician, iso-practice-setting and iso-specialty combinations of one 30-patient-limit observation and one 100-patient-limit observation. The following independent difference variables were calculated: the elapsed number of years (not necessarily an integer) between the two observations (*Time_Diff*), a dummy variable indicating whether the physician reported turning down any positive number of patients in the second of the two observations (*TurnDownAfter*), and a dummy variable indicating the addition of a certification in addiction medicine between the two observations (*Add_Cert_Gain*). The other independent variables were retained from the earlier of the two observations and the variables from the latter observation were deleted. Table 6.2 summarizes all of the independent variables used in the three experiments.

TABLE 6.2 – Independent Variables	
Variable	**Meaning**
Sp_Addict	Equals 1 if the physician indicated addiction medicine as a primary specialty.
Sp_PCPtype	Equals 1 if the physician indicated internal medicine, family medicine or pediatrics as a primary specialty.
Sp_Anesth	Equals 1 if the physician indicated anesthesia as a primary specialty.
Sp_PainMed	Equals 1 if the physician indicated pain medicine as a primary specialty.
Sp_Psychiatry	Equals 1 if the physician indicated psychiatry as a primary specialty.
Add_Cert	Equals 1 if the physician indicated one of three board certifications in addiction medicine.
Set_Mul	Equals 1 if the physician identified a multi-specialty group practice as the primary practice setting.
Set_Sha	Equals 1 if the physician identified a solo practice in a space shared with other physicians as the primary practice setting.
Set_Sin	Equals 1 if the physician identified a single-specialty group practice as the primary practice setting.
Set_Sol	Equals 1 if the physician identified a solo practice as the primary practice setting.
Set_Sta	Equals 1 if the physician identified a staff-model HMO as the primary practice setting.
Region_W	Equals 1 if the physician was located in the “West” region, as identified by the Census.
Region_MW	Equals 1 if the physician was located in the “Midwest” region, as identified by the Census.
Region_NE	Equals 1 if the physician was located in the “Northeast” region, as identified by the Census.
Region_S	Equals 1 if the physician was located in the “South” region, as identified by the Census.
Yr2007	Equals 1 if the observation occurred in calendar year 2007.
Yr2008	Equals 1 if the observation occurred in calendar year 2008.
Yr2009	Equals 1 if the observation occurred in calendar year 2009.
Yr2010	Equals 1 if the observation occurred in calendar year 2010.

TABLE 6.2 – Independent Variables, continued	
PercentPract	Equals 0 if the physician indicated that 0% of the total medical practice was devoted to treating substance abuse patients; equals 1 if the physician indicated 1 – 20%; equals 2 if the physician indicated 21 – 40%; equals 3 if the physician indicated 41 – 60%; equals 4 if the physician indicated 61 – 80%; equals 5 if the physician indicated 81 – 100%.
Yrs_Practicing	The number of years for which the physician has been practicing medicine at the time of the observation.
X_is_100	Equals 1 if the physician faced a caseload maximum of 100 patients at the time of the observation.
Limit_MED	Equals 1 if the physician indicated that any issues related to the medicine itself represent limitations associated with buprenorphine maintenance treatment.
Limit_FIN	Equals 1 if the physician indicated that any issues related to financial considerations represent limitations associated with buprenorphine maintenance treatment.
Independent variables specific to Experiment #2	
Time_Diff	Equals the number of years (not necessarily an integer) elapsed between the two observations.
Add_Cert_Gain	Equals 1 if the physician indicated holding one of three board certifications in addiction medicine in the second, but not first, of the two observations.
TurnDownAfter	Equals 1 if the physician indicated turning down any positive number of patients due to the caseload maximum in the second of the two observations.

The creation of the dependent variables was relatively straightforward. In some survey waves, the physician was asked directly about the number of patients on “Withdrawal” or “Maintenance” regimens, so for these waves, the simple answer to the latter question was retained as the number of maintenance patients. This number was subtracted from the number of total current buprenorphine patients (the sum of the number of patients on Subutex and the number of patients on Suboxone) to determine the number of non-maintenance patients. In other survey waves, the stages of treatment from which the physician could choose were given as “Induction,” “Maintenance” or “Dose Tapering.” The number of patients in the maintenance phase was retained without change. Induction implies that the patient is in the first stage of treatment. Dose tapering can occur at the end of induction and stabilization or, sometimes, at the end of an extended period of time on maintenance. Most importantly, however, dose tapering indicates that the physician does not intend to further maintain a long-term relationship with this patient, regardless of the past history between patient and physician, so the number of patients in the “dose tapering” phase of treatment was combined with the number of patients in the “induction” phase of treatment to determine the number of non-maintenance patients. Two variables were created for every observation: *MainCurr*, the current number of patients being maintained, and *NonMCurr*, the current number of non-maintenance patients.

For Experiment #1, the dependent variable is *MainCurr*; for Experiment #3, the dependent variable is *NonMCurr*. In both cases, the natural log of these patient counts were also calculated, and labeled *ln_MainCurr* and *ln_NonMCurr*. For Experiment #2, the dependent variables under consideration are both the difference in maintenance patients between observations and the difference in non-maintenance patients between observations, *Main_diff* and *NonM_diff*. Natural logs cannot be computed because in some cases the difference is negative or zero.

Table 6.3 below gives the mean and standard deviation for all of the variables (dependent and independent) that entered into the regression for Experiment #1. As seen in Table 6.3, for Experiment #1, 46% of the respondents indicated a primary-care-type specialty, and 37% reported psychiatry as a primary specialty. Thirty-eight percent reported holding a certification in addiction medicine. The most popular practice setting was a solo practice (about 45%), followed by a single-specialty group practice (21%). Observations were distributed relatively well across regions and years. Only slightly more than half of the observations (53%) were observations where the physician likely faced a caseload maximum of 100 patients at the time of observation.

TABLE 6.3 – Descriptive Statistics for Experiment #1

Variable	Mean	St. Dev.
MainCurr	18.9505	18.2084
ln_MainCurr	2.4238	1.1195
Sp_Addict	0.2790	0.4486
Sp_PCPtype	0.4613	0.4986
Sp_Anesth	0.0245	0.1547
Sp_CommHealth	0.0034	0.0579
Sp_Neurology	0.0115	0.1068
Sp_PainMed	0.1174	0.3219
Sp_Psychiatry	0.3733	0.4838
Add_Cert	0.3805	0.4856
Set_Mul	0.0976	0.2969
Set_Sha	0.1025	0.3033
Set_Sin	0.2145	0.4106
Set_Sol	0.4459	0.4972
Set_Sta	0.0067	0.0818
Region_W	0.2136	0.4099
Region_MW	0.1837	0.3874
Region_NE	0.3155	0.4648
Region_S	0.2795	0.4488
Yr2007	0.1015	0.3021
Yr2008	0.2468	0.4312
Yr2009	0.2742	0.4462
Yr2010	0.2458	0.4307
PercentPract	2.8942	1.2961
Yrs_Practicing	20.3427	10.9309
X_is_100	0.5310	0.4992
Limit_MED	0.1448	0.3520
Limit_FIN	0.7730	0.4190

Table 6.4 below provides descriptive statistics for the 75 observations associated with Experiment #2. The mean difference for both patient types is positive, which indicates that, at least on average, physicians who face a higher caseload maximum treat more maintenance and non-maintenance patients. The three specialties represented in the data are all well-represented. Just over half of the physicians (about 53%) are certified in addiction medicine at the time of the first observation. Most of the observations are for physicians in solo practices (59%).

TABLE 6.4 - Descriptive Statistics for Experiment #2

Variable	Mean	St. Dev.
NonM_diff	6.3200	15.7593
Main_diff	24.1733	25.4704
Sp_Addict	0.4933	0.5033
Sp_PCPtype	0.4800	0.5030
Sp_Psychiatry	0.3200	0.4696
Time_Diff	2.7237	1.0420
Add_Cert_Gain	0.0667	0.2511
Add_Cert	0.5333	0.5022
Set_Sin	0.1067	0.3108
Set_Sol	0.5867	0.4957
Set_Sta	0.0267	0.1622
Region_W	0.1467	0.3562
Region_MW	0.2800	0.4520
Region_NE	0.3467	0.4791
PercentPract	3.5467	1.6627
Yrs_Practicing	19.6785	9.5725
TurnDownAfter	0.2533	0.4378
Limit_MED	0.0267	0.1622
Limit_FIN	0.7600	0.4300

Table 6.5 below provides descriptive statistics for Experiment #3. The table shows that addiction specialty, primary-care type specialties and psychiatry are the most popular, having been selected by 36%, 39% and 42% of the responding physicians respectively. About 42% of the physicians hold a board certification in addiction medicine. Solo practices were the most frequent (29%), followed by single-specialty group practices (19%). About a third of the observations come from 2006 or 2007, and the other two-thirds come from 2008 – 2010.

Only 18.5% of the observations in Experiment #3 occurred under an imputed caseload maximum of 100 patients, which is significantly lower than Experiment #1's 53%. This underscores the possibility that physicians operating under a caseload maximum of 100 are likely to treat maintenance and non-maintenance patients. A subsample of physicians that chooses not to maintain patients is more likely going to include physicians that face a caseload maximum of 30. It could also be that this sample is self-selecting. Physicians who do not plan on maintaining patients are less likely to perform a second notification in order to treat up to 100 patients.

6.3 ECONOMETRIC METHODS

Due to the panel nature of the survey data, it is possible that the errors in the data are not independent and identically-distributed, a requirement of ordinary least squares estimation. Though it has been argued (Gujarati, 2009) that the existence of heteroskedasticity impacts only the standard errors (and thus inferences) of a regression model, without impacting the coefficient estimates, Goodman and Thibodeau (1995) have pointed out that inaccurate characterization of the variance can lead to parameter estimates that are likewise inaccurate. For the sake of accurate parameter estimates and proper inference, the possibility of heteroskedasticity was explored for the data in all three experiments.

TABLE 6.5 - Descriptive Statistics for Experiment #3		
Variable	**Mean**	**St. Dev.**
NonMCurr	6.6641	10.6883
ln_NonMCurr	1.2394	1.0873
Sp_Addict	0.3591	0.4807
Sp_PCPtype	0.3861	0.4878
Sp_Anesth	0.0232	0.1507
Sp_PainMed	0.0656	0.2481
Sp_Psychiatry	0.4170	0.4940
Add_Cert	0.4170	0.4940
Set_Mul	0.0734	0.2612
Set_Sha	0.0463	0.2106
Set_Sin	0.1853	0.3893
Set_Sol	0.2934	0.4562
Set_Sta	0.0309	0.1733
Region_W	0.2394	0.4275
Region_MW	0.1506	0.3583
Region_NE	0.2934	0.4562
Region_S	0.3050	0.4613
Yr2007	0.0965	0.2959
Yr2008	0.2124	0.4098
Yr2009	0.2355	0.4251
Yr2010	0.2317	0.4227
PercentPract	3.4440	1.6518
Yrs_Practicing	21.5844	12.3569
X_is_100	0.1853	0.3893
Limit_MED	0.2432	0.4299
Limit_FIN	0.6255	0.4849

Standard White tests (White, 1980) for heteroskedasticity were performed for the data used in all of the Experiments, and the results are given in Tables 6.6, 6.7 and 6.8 below. To perform the White test, the squared residuals from an OLS estimation of the data are regressed against all of the regressors (and cross-products of the regressors) from the original equation. Then, the *LM* statistic is calculated as $n \times R^2$, where n is the number of observations and R^2 is the R^2 from the second regression of the squared residuals. This statistic has a χ^2 distribution with degrees of freedom equal to the number of regressors in the auxiliary squared residuals equation minus one.

The null hypothesis of the White test is that there is no heteroskedasticity. One compares the *LM* test statistic to the critical χ^2 value and rejects the null hypothesis if the *LM* statistic is greater than the critical value. In other words, if the *LM* statistic is higher than the critical value, then the null hypothesis of no heteroskedasticity can be rejected in favor of the alternative hypothesis that the data display heteroskedasticity.

TABLE 6.6 – White test for Heteroskedasticity for the data from Experiment #1

Dependent variable specification	*n*	R^2 of auxiliary regression	*LM* test statistic	*DF*	Critical χ^2 value at 10%	Critical χ^2 value at 5%
Natural log of patient count	2,080	0.1125	234.0	248	276.9	285.7
	Result: The null hypothesis of no heteroskedasticity cannot be rejected.					
Patient count	2,080	0.2425	504.4	248	276.9	285.7
	Result: The null hypothesis of no heteroskedasticity can be rejected at the 5% confidence level. There is sufficient reason to believe that heteroskedasticity exists.					

TABLE 6.7 – White test for Heteroskedasticity for the data from Experiment #2						
Dependent variable	***n***	**R^2 of auxiliary regression**	***LM* test statistic**	***DF***	**Critical χ^2 value at 10%**	**Critical χ^2 value at 5%**
Difference in Non-Maintenance Patients	75	0.9013	67.5975	69	84.42	89.39
	Result: The null hypothesis of no heteroskedasticity cannot be rejected.					
Difference in Maintenance Patients	75	0.9336	70.0200	69	84.42	89.39
	Result: The null hypothesis of no heteroskedasticity cannot be rejected.					

TABLE 6.8 – White test for Heteroskedasticity for the data from Experiment #3						
Dependent variable specification	***n***	**R^2 of auxiliary regression**	***LM* test statistic**	***DF***	**Critical χ^2 value at 10%**	**Critical χ^2 value at 5%**
Natural log of patient count	259	0.3719	213.9757	184	209.0	216.6
	Result: The null hypothesis of no heteroskedasticity can be rejected at the 10% confidence level, but not at the 5% level. There is some reason to believe that heteroskedasticity exists.					
Patient count	259	0.5767	227.9718	184	209.0	216.6
	Result: The null hypothesis of no heteroskedasticity can be rejected at the 5% confidence level. There is sufficient reason to believe that heteroskedasticity exists.					

Ordinarily, the number of regressors in the auxiliary regression would be equal to $(k^2 + 3k)/2$, where k is the number of regressors in the original OLS regression. In these cases, however, the number of regressors in each auxiliary regression is smaller than this for two reasons, both related to the binary nature of many of the independent variables. The square of a binary variable would not be a unique variable, so it would not be included. Also, the cross-products of many of the regressors were eliminated by the statistical software for creating variables that were either not unique or were linear combinations of other variables. The degrees of freedom reported in the tables above are based on the number of regressors that the statistical software used in the regression.

The results of the White tests on the data for Experiment #1 (Table 6.6) were mixed; heteroskedasticity appears to be present in the data if the dependent variable is simply patient count, but not if the dependent variable is the natural log of patient count.

The results for the White test on the data for Experiment #2 (Table 6.7) require some explanation. Because of the regrettably low number of observations for Experiment #2 (due to the restrictive definition of the subsample based on the KT conditions) and the fact that the number of regressors in the auxiliary regression is relatively high, rejection of the null hypothesis of no heteroskedasticity is mathematically impossible. The upper bound of the LM test statistic is 75—and the calculated test statistic is near to this upper bound—but the critical χ^2 values are 84.42 and 89.39. For this reason, though the alternative hypothesis of heteroskedasticity is not statistically accepted, the possibility of heteroskedasticity, and the need to correct it, will not be entirely ruled out.

The results for the White test on the data for Experiment 3 (Table 6.8) confirm that heteroskedasticity is likely present in the sample data. This offers further support that heteroskedasticity could exist in the data for the first two experiments.

Because of the mixed or ambiguous results in some cases above, the regression analysis was performed using a number of approaches to correcting for heteroskedasticity, and the results from these approaches will be reported. One simple approach to correcting for heteroskedasticity is to calculate what are known as heteroskedasticity-consistent (or “White”) standard errors. The statistical software makes this task very simple. It calculates new standard errors so that proper inferences can be made, but parameter estimates are identical to those that would be achieved through regular OLS estimation.

One other approach to correcting for heteroskedasticity is the one used by Goodman and Thibodeau (1995), which comes from Davidian and Carroll (1987). This approach requires iterative regressions. First, OLS methods are used to estimate the original regression equation, and the residuals are retained. Then, the absolute values of these residuals are regressed against variables from the original equation that are thought to be related to the heteroskedasticity. From this second regression, predicted values of the dependent variable (absolute values of residuals) are retained. These inverses of these predicted values are then used as weights in a weighted least squares estimation of the original regression. This process is iterated until the parameter estimates of the weighted least squares estimations converge and fail to be improved by further iterations.

So for each of the three experiments, three sets of results are given: simple OLS estimates with unadjusted standard errors, OLS estimates with White standard errors, and the weighted least squares estimates from the final converged regression based on the iterative approach suggested by Davidian and Carroll (1987).

CHAPTER 7: RESULTS

7.1 RESULTS FROM EXPERIMENT #1 ON MAINTENANCE PATIENTS

Experiment #1 focused on the number of patients maintained on buprenorphine by physicians who reported having both maintenance and non-maintenance patients but who did not treat the maximum allowable number of patients. The empirical results from Experiment #1, which had 2,080 observations, are given in Tables 7.1 and 7.2 below. Table 7.1 provides the results for the specification that used the patient count as the dependent variable; Table 7.2 provides the results for the specification that used the natural log of the patient count as the dependent variables. In both cases, the region dummy coefficients should be interpreted relative to the excluded regions—Pacific and the Caribbean. The year dummy coefficients should be interpreted relative to the excluded year, 2006. The practice setting dummy variable coefficients should be interpreted relative to a hospital setting, the setting which was not included. Finally, the *X_is_100* variable coefficients are relative to a caseload limit of 30.

Section 4.5.1 gave the hypotheses for Experiment #1. With respect to specialty, it was hypothesized that physicians with PCP-type specialties would be expected to have more patients on maintenance, relative to physicians in other specialties; physicians with psychiatry as a primary specialty would be expected to have fewer patients on maintenance, relative to physicians in other specialties; and physicians who are addiction specialists, certified in addiction medicine, or devote more of their practice to treating substance abusing patients would be expected to have more patients on maintenance, relative to other physicians.

TABLE 7.1 – Patient Count Results from Experiment #1

Dependent variable: Current Maintenance Patients, *MainCurr*

n =2,079	Ordinary Least Squares			Weighted Least Squares	
	R^2: 0.3640	Adj. R^2: 0.3559		R^2: 0.428	Adj. R^2: 0.4208
Independent Variable	**Parameter Estimate**	**Standard Error**	**White Standard Error**	**Parameter Estimate**	**Standard Error**
Intercept	-4.6175	4.2172	2.8757	0.5553	2.6732
Sp_Addict	1.3416	0.8765	0.8970	0.7526	0.6815
Sp_PCPtype	1.8228	1.0869*	1.1574	1.6764	0.8577*
Sp_Anesth	-2.5694	2.2611	1.6487	-1.3372	1.3072
Sp_CommHealth	1.8790	5.6020	4.3185	1.6919	4.1856
Sp_Neurology	-1.0894	3.0759	2.1334	-2.3333	1.7950
Sp_PainMed	0.9934	1.2251	1.2407	0.3405	0.9182
Sp_Psychiatry	-2.7136	1.0746**	1.1203**	-1.4460	0.8298*
Add_Cert	0.8857	0.7222	0.7067	0.8565	0.5481
Set_Mul	1.6358	1.3904	1.3216	0.6147	0.9850
Set_Sha	0.5329	1.3873	1.2913	0.3062	0.9993
Set_Sin	1.7592	1.1659	1.0625*	1.2406	0.8353
Set_Sol	0.8288	1.0634	0.9687	0.1709	0.7463
Set_Sta	2.2028	4.0739	4.9689	0.8469	3.4745
Region_W	4.1337	3.7859	2.3138*	1.2937	2.2897
Region_MW	5.2016	3.8011	2.3563**	1.9849	2.3084
Region_NE	6.3479	3.7716*	2.2646***	2.7522	2.2679
Region_S	5.1203	3.7647	2.2624**	1.7229	2.2600
Yr2007	-2.4553	1.4449*	1.2410**	-1.5606	1.0588
Yr2008	-0.9776	1.1917	0.7634	-0.4559	0.7696
Yr2009	1.1283	1.1783	0.7410	0.2700	0.7695
Yr2010	0.8537	1.1779	0.7349	0.4239	0.7550
PercentPract	1.5224	0.3172***	0.3328***	1.2319	0.2576***
Yrs_Practicing	0.0516	0.0303*	0.0305*	0.0256	0.0230
X_is_100	19.8056	0.7321***	0.6314***	19.7569	0.5996***
Limit_MED	-2.7867	0.9197***	0.9031***	-1.1430	0.6839*
Limit_FIN	1.4670	0.7894*	0.7635*	1.1530	0.5752**

* Significant at 10%, ** Significant at 5%, *** Significant at 1%

Some of these hypotheses are confirmed by the empirical results. The patient-count specification reported in Table 7.1 confirms that the coefficient on *Sp_PCPtype* is positive and statistically significant in two of the three regressions. *Sp_Psychiatry* is negative and statistically significant in all three regressions. Though *Sp_Addict* and *Add_Cert* fail to rise to statistical significance in any of the regressions, they both have the right sign. Most importantly, *PercentPract* is positive and statistically significant in all three regressions.

Turning to the natural-log specifications reported in Table 7.2, the variable *Sp_PCPtype* is again positive and statistically significant in all three regressions. A physician in a primary-care-type specialty keeps 14% to 15% more patients on maintenance than does a physician not in one of these specialties. In the natural log specification, the impact of a psychiatry specialty is not statistically significant at all. The variable related to the percentage of a physician's practice dedicated to substance abuse patients is positive and statistically significant. Simply interpreted, a 20% increase in the amount of his or her practice a physician dedicates to substance abuse leads to a 9% increase in the number of patients treated through maintenance.

In general, the empirical results confirm the hypothesized effects of physician specialty on the number of patients a physician will keep on maintenance: addiction specialists and physicians with low market power will keep more patients on maintenance; there is limited evidence that psychiatrists will keep fewer patients on maintenance.

TABLE 7.2 – Natural Log of Patient Count Results from Experiment #1					
Dependent variable: Natural Log of Current Maintenance Patients, *ln_MainCurr*					
n = 2,079	**Ordinary Least Squares**			**Weighted Least Squares**	
	R^2: 0.3770	Adj. R^2: 0.3691		R^2: 0.3829	Adj. R^2: 0.375
Independent Variable	**Parameter Estimate**	**Standard Error**	**White Standard Error**	**Parameter Estimate**	**Standard Error**
Intercept	1.0782	0.2566***	0.2302***	1.0742	0.2413***
Sp_Addict	0.0657	0.0533	0.0525	0.0680	0.0526
Sp_PCPtype	0.1303	0.0661**	0.0656**	0.1360	0.0654**
Sp_Anesth	-0.0717	0.1376	0.1203	-0.0800	0.1229
Sp_CommHealth	0.3552	0.3409	0.2398	0.3102	0.2951
Sp_Neurology	-0.0630	0.1872	0.1814	-0.0653	0.1878
Sp_PainMed	0.0567	0.0745	0.0705	0.0696	0.0721
Sp_Psychiatry	-0.1025	0.0654	0.0647	-0.1021	0.0648
Add_Cert	0.0595	0.0439	0.0438	0.0583	0.0436
Set_Mul	0.0975	0.0846	0.0819	0.0962	0.0837
Set_Sha	-0.0103	0.0844	0.0852	-0.0053	0.0850
Set_Sin	0.0811	0.0709	0.0697	0.0865	0.0707
Set_Sol	0.0266	0.0647	0.0626	0.0213	0.0643
Set_Sta	-0.0621	0.2479	0.2702	-0.0433	0.2642
Region_W	0.1771	0.2304	0.2095	0.1656	0.2134
Region_MW	0.2299	0.2313	0.2102	0.2190	0.2142
Region_NE	0.3404	0.2295	0.2080	0.3286	0.2121
Region_S	0.2114	0.2291	0.2071	0.1989	0.2119
Yr2007	-0.2127	0.0879**	0.0915**	-0.2072	0.0908**
Yr2008	-0.0940	0.0725	0.0718	-0.0869	0.0735
Yr2009	-0.0014	0.0717	0.0710	0.0117	0.0722
Yr2010	0.0146	0.0717	0.0701	0.0221	0.0719
PercentPract	0.0843	0.0193***	0.019***	0.0853	0.0190***
Yrs_Practicing	0.0010	0.0018	0.0018	0.0009	0.0018
X_is_100	1.2769	0.0446***	0.0442***	1.2801	0.0443***
Limit_MED	-0.1502	0.056***	0.0593**	-0.1512	0.0572***
Limit_FIN	0.1491	0.048***	0.0493***	0.1502	0.0494***
* Significant at 10%, ** Significant at 5%, *** Significant at 1%					

In both specifications—patient count (Table 7.1) and natural log (Table 7.2), practice setting fails to have any noticeable impact. The only exception is that the coefficient associated with a single-specialty group practice is positive and statistically significant in the OLS specification using White standard errors with patient-count as the dependent variable (Table 7.1). It was hypothesized in Section 4.5.1 that physicians in solo practices or single-specialty group practices, where there is less potential for external costs to spill over into unrelated practices, would be expected to keep more patients on maintenance. This one significant coefficient is consistent with that hypothesis.

It was hypothesized that physicians with more years of experience would be expected to keep more patients on maintenance. Table 7.1 reports that the coefficient on the variable *Yrs_Practicing* is positive and statistically significant in the OLS specification, regardless of the standard errors employed. Another two years of experience leads to one additional maintenance patient, on average.

In the patient-count OLS specifications (Table 7.1), some of the region variables were also statistically significant. There were no hypotheses regarding these variables, but it is interesting to note that this implies that physicians in the continental U.S. keep more patients on maintenance than do other U.S. physicians. The variable for *Yr2007* was also statistically significant for five of the six total specifications. Its sign is negative, indicating that physicians kept fewer patients on maintenance in 2007 than in 2006. There is no obvious explanation for why this might have been.

The two included variables that reflect physician attitudes are also statistically significant. This is so for all of the specifications. The natural-log specification (Table 7.2) provides the best interpretation of the results. When the physician views the medicine itself as a limitation, the number of patients on maintenance falls by 14%; when the physician views financial issues, such as reimbursement, as limitations, the number of patients on maintenance is higher by 16%. This latter result could be the result of endogeneity, suggesting that physicians who maintain a higher number of patients are more likely to run into the financial issues surrounding the use of buprenorphine. At the very least, this result suggests that financial issues are not sufficient to prevent physicians from using buprenorphine to treat patients.

The dummy variable *X_is_100* is positive and statistically significant in all six specifications. This means that physicians who face a caseload maximum of 100 patients, rather than just 30, kept more patients on maintenance. In fact, Table 7.2 confirms that when the patient caseload maximum is 100 rather than 30, the number of patients kept on maintenance increases by about 260%.

The empirical results of Experiment #1, which focused on the number of maintenance patients for physicians with patients of both types, generally confirm the results predicted by the algebraic model presented in Chapter 4. Physician specialty is related to market power and opportunity cost as hypothesized in Chapter 4: physicians in primary-care type specialties and physicians who specialize in addiction treatment keep more patients on maintenance relative to other physicians; psychiatrists keep fewer patients on maintenance. There is limited evidence that practice setting affects treatment costs. Experience practicing medicine reduces opportunity costs of treating patients for substance abuse, and more experienced physicians treat more patients. Most notably, physicians keep more than 3.5 times as many patients on maintenance treatment when the caseload maximum increases to 3.33 times the lower 30-patient limit.

7.2 RESULTS FROM EXPERIMENT #2 ON RESPONSE TO CASELOAD LIMIT INCREASE

The empirical results from Experiment #2 are given in Tables 7.3 and 7.4 below. Experiment #2 focused on the differences in the numbers of maintenance and non-maintenance patients for physicians who appear to be bound by the federal caseload maximum. In essence, this experiment tested most directly the impact of the change in the caseload maximum on physician treatment choices. The variable *Region_South* was omitted. Due to the very small number of observations, many specialties were omitted.

The very small sample size (n = 75) prevented this experiment from yielding substantial results. Table 7.3 focuses on the difference in non-maintenance patients. Non-maintenance patients include new patients in the induction and stabilization phases of treatment as well as patients being withdrawn from buprenorphine. The coefficient on the variable *Sp_PCPtype* is positive and statistically significant in one of three specifications. This result suggests that a physician in one of these specialties will have almost 7 more non-maintenance patients after an increase in the maximum allowable caseload from 30 to 100. Table 7.3 also reports that psychiatrists increase the number of non-maintenance patients by 10 after an increase in the caseload maximum. Likewise, the coefficient on the variable *Set_Sin*, which indicates a single-specialty group practice, is positive and statistically significant. These physicians increase non-maintenance caseloads by 16.9 to 17.9 patients in response to the caseload maximum increase. These results do not conform to the prediction generated by the algebraic model that the number of non-maintenance patients should decrease. This discrepancy could be due to the fact that an increase from 30 to 100 represents much more than a marginal increase, so that had the limit increased only by a few patients, the algebraic model would be more relevant.

TABLE 7.3 – Non-Maintenance Patients Difference Results from Experiment #2					
Dependent variable: The difference in non-maintenance patients between observations, *NonM_diff*					
n = 75	**Ordinary Least Squares**			**Weighted Least Squares**	
	R^2: 0.2815	Adj. R^2: 0.0672		R^2: 0.2814	Adj. R^2: 0.0671
Independent Variable	**Parameter Estimate**	**Standard Error**	**White Standard Error**	**Parameter Estimate**	**Standard Error**
Intercept	-9.4865	11.8888	10.2594	-8.0099	11.7294
Sp_Addict	5.8353	5.1419	3.7658	6.8541	4.7945
Sp_PCPtype	6.8875	4.7898	3.6281*	6.3691	4.6468
Sp_Psychiatry	10.2896	5.1701*	3.9710**	10.2073	4.7839**
Time_Diff	1.1783	1.8350	1.6777	0.4541	1.7643
Add_Cert_Gain	9.1702	8.1560	8.7051	6.5676	8.0527
Add_Cert	0.7293	4.9898	4.2770	0.2572	4.7754
Set_Sin	17.8606	8.0488**	9.0987*	16.8705	7.5820**
Set_Sol	5.7299	4.9673	3.4955	6.4812	4.7227
Set_Sta	4.5977	13.2435	8.2844	5.2028	12.2350
Region_W	9.8566	7.5182	6.7491	10.0510	7.4877
Region_MW	-2.0078	6.2128	4.6478	-1.5597	6.2296
Region_NE	3.5095	5.3772	5.1896	3.8978	5.4687
PercentPract	-0.0245	1.5920	1.2541	-0.2101	1.5418
Yrs_Practicing	0.1962	0.2327	0.2158	0.1646	0.2335
TurnDownAfter	4.3206	4.6059	4.2064	4.9112	4.4787
Limit_MED	-3.4982	12.8477	12.5874	-1.3093	13.1158
Limit_FIN	-13.3488	4.6928***	4.1454***	-11.8666	4.5414**
* Significant at 10%, ** Significant at 5%, *** Significant at 1%					

While physicians in primary-care type specialties and psychiatrists are not alike with respect to market power, they may be alike with respect to marginal treatment costs. For primary care physicians, the opportunity cost of treating opioid dependence may be low since they often treat a wide range of a patient's health-related problems. For psychiatrists, training may reduce the marginal cost of providing medication-assisted opioid dependence treatment. The lower marginal costs of treatment may explain why these physicians increase their patient counts so dramatically relative to physicians in other specialties. If lower marginal costs of treatment are also the reason for the positive coefficient on *Set_Sin*, then this could reveal that in single-specialty group practices where buprenorphine treatment is being provided, there is consensus about and openness to treating opioid dependence, so the possibility for external costs to spill over onto other physicians is low.

Interestingly, Table 7.3 reports that the coefficient on *Limit_FIN* is statistically significant in all three specifications and negative. This means that physicians who reported that the financial issues—such as third party reimbursement—presented significant limitations to the use of buprenorphine had fewer non-maintenance patients (between 11.9 and 13.3 fewer) after the increase in the caseload maximum, compared to before the increase. So while Experiment #1 above suggested that financial considerations may not be enough to prevent physicians from maintaining a high number of patients, this result suggests that, over time, these issues can cause physicians to reduce the number of non-maintenance patients.

Turning to the results for the difference in the number of maintenance patients (Table 7.4), the most substantial result is the positive coefficient on the *Sp_PCPtype* variable, which is statistically significant with or without corrections for heteroskedasticity. The results suggest that physicians in internal medicine, family medicine or pediatrics keep between 18.7 and 19.5 additional patients on maintenance after an increase in the caseload maximum. The coefficient on *Sp_Psychiatry* is also positive and statistically significant, suggesting that psychiatrists keep about 15 more patients on maintenance after an increase in the caseload maximum. This conforms to the hypothesis from Section 4.5.2 that the number of maintenance patients would be expected to increase after an increase in the caseload maximum.

TABLE 7.4 – Maintenance Patients Difference Results from Experiment #2					
Dependent variable: The difference in maintenance patients between observations, *Main_diff*					
n = 75	**Ordinary Least Squares**			**Weighted Least Squares**	
	R^2: 0.4057	Adj. R^2: 0.2284		R^2: 0.4090	Adj. R^2: 0.2327
Independent Variable	**Parameter Estimate**	**Standard Error**	**White Standard Error**	**Parameter Estimate**	**Standard Error**
Intercept	-21.3940	17.4757	14.8984	-22.4462	17.2429
Sp_Addict	-3.7654	7.5583	6.3864	-3.1172	7.4343
Sp_PCPtype	18.7017	7.0406**	6.9477***	19.5343	7.0526***
Sp_Psychiatry	15.1681	7.5996*	6.7083**	15.0369	7.4286**
Time_Diff	7.4668	2.6973***	2.6320***	7.3420	2.6852***
Add_Cert_Gain	3.4214	11.9888	7.6566	3.6423	11.5307
Add_Cert	-1.8874	7.3347	6.3219	-1.9010	7.2513
Set_Sin	-3.0160	11.8311	8.8848	-2.2283	11.4615
Set_Sol	-0.1373	7.3017	7.1762	0.4200	7.0994
Set_Sta	-8.4349	19.4670	10.6289	-8.7697	19.5106
Region_W	-16.8043	11.0513	10.7311	-15.6269	10.8789
Region_MW	-10.2283	9.1324	9.7454	-11.0882	9.1349
Region_NE	-12.6937	7.9042	7.9867	-12.7439	7.9479
PercentPract	-0.0868	2.3401	1.8473	0.2241	2.3526
Yrs_Practicing	1.0527	0.3421***	0.3321***	1.0108	0.3430***
TurnDownAfter	7.4130	6.7704	7.2795	7.8099	6.6598
Limit_MED	-0.3607	18.8853	11.7735	1.0098	18.4480
Limit_FIN	2.7843	6.8982	4.9328	2.7500	6.7685
* Significant at 10%, ** Significant at 5%, *** Significant at 1%					

Additionally, these two positive physician-specialty results are consistent with the results from the non-maintenance side of this experiment (in Table 7.3) with two notable differences. First, the magnitudes of the coefficients are greater in Table 7.4. This means that, while these physicians increase their non-maintenance and maintenance caseloads after an increase in the maximum total caseload, the increases in maintenance are greater. This is partially in line with the predictions of the algebraic model that maintenance caseloads should increase and non-maintenance caseloads should decrease. Second, the coefficient on *Sp_PCPtype* is the greater of the two in Table 7.4 and the smaller of the two in Table 7.3. This means that the non-maintenance versus maintenance differential is greater for primary-care physicians. After the increase in the caseload maximum, psychiatrists add to their caseloads about 1.5 maintenance patients for every non-maintenance patient, but physicians in primary-care type specialties (internal medicine, family medicine, pediatrics) add almost 3 maintenance patients for every added non-maintenance patient.

The variable *Time_Diff* has a positive and statistically significant in all three specifications. This simply reflects the time needed to acquire more patients and to move them from induction and stabilization to maintenance. For each additional year (quarter) between observations, the physician’s maintenance caseload increased by about 7.4 patients (1.9 patients).

Finally, the coefficient on the variable *Yrs_Practicing* is positive and statistically significant in all three specifications. For every year of experience, a physician adds another 1 maintenance patient as a result of a caseload maximum increase from 30 to 100. The mean number of years of experience in this experiment (see Table 6.4) was 19.7.

The primary result of the algebraic model was that the number of non-maintenance patients should fall, and the number of maintenance patients should rise, after an increase in the caseload maximum. These conclusions would have been most strongly supported by a negative and statistically significant intercept for the *NonM_diff* model (Table 7.3), and a positive and statistically significant intercept for the *Main_diff* model (Table 7.4). Both intercepts were calculated to be negative and neither was statistically significant. However, it should be noted that the estimated coefficients on the variables such as *Sp_PCPtype*, *Sp_Psychiatry*, *TimeDiff* and, most importantly, *Yrs_Practicing* in the *Main_diff* model are large enough in magnitude to cause the change in the number of patients on maintenance to be positive, even in spite of the negative intercept. So for many physicians, a higher caseload maximum leads to more patients on maintenance.

7.3 RESULTS FROM EXPERIMENT #3 ON NON-MAINTENANCE PATIENTS

The empirical results from Experiment #3 are given in Tables 7.5 and 7.6 below. Experiment #3, with a sample size of 259 observations, focused on physicians who reported having no patients on maintenance but treated fewer non-maintenance patients than the federal caseload maximum. Non-maintenance patients include new patients in the induction and stabilization phases of treatment as well as patients being withdrawn from buprenorphine. As in Section 7.1, the omitted dummies are the Pacific and Caribbean for region, 2006 for year, hospital for practice setting, and 30 for the caseload maximum.

Section 4.5.3 provides several hypotheses for the results of Experiment #3. The first hypothesis involved physicians with PCP-type specialties. It was hypothesized that these physicians would treat more non-maintenance patients, all else equal, than other physicians. The coefficient on the *Sp_PCPtype* variable is only significant in the natural-log specification, and only under the condition that heteroskedasticity is not corrected for. According to Table 6.8, the null hypothesis of no heteroskedasticity can be rejected at 10% confidence, but not 5%. (In the other specifications, the coefficient has the appropriate sign, but is not statistically significant.) According to the OLS result in Table 7.6, a physician in these specialties would treat 40% more non-maintenance patients than a physician not in these specialties, consistent with the model results from Section 4.5.3.

TABLE 7.5 – Patient Count Results from Experiment #3					
Dependent variable: Current Non-Maintenance Patients, *NonMCurr*					
n = 259	**Ordinary Least Squares**			**Weighted Least Squares**	
	R^2: 0.2046	Adj. R^2: 0.1230		R^2: 0.3581	Adj. R^2: 0.2896
Independent Variable	**Parameter Estimate**	**Standard Error**	**White Standard Error**	**Parameter Estimate**	**Standard Error**
Intercept	-5.5154	6.9846	4.2637	-4.0986	6.4943
Sp_Addict	2.5705	1.7635	1.7466	3.2286	1.1165***
Sp_PCPtype	2.7064	1.9077	1.7869	0.1035	1.1925
Sp_Anesth	-7.0428	4.5830	4.6536	1.2717	2.0639
Sp_PainMed	7.7793	3.1477**	5.2499	1.9511	2.7394
Sp_Psychiatry	3.1647	1.8810*	1.5925**	1.5949	1.1328
Add_Cert	1.1245	1.4516	1.7194	-0.9459	0.9332
Set_Mul	0.8037	2.6677	1.9870	1.2209	1.7460
Set_Sha	-2.0502	3.1963	1.4324	-0.7966	1.6009
Set_Sin	1.6131	1.9898	1.8172	-0.1775	1.2527
Set_Sol	1.1029	1.7664	1.6989	-0.4172	1.0742
Set_Sta	-1.3634	4.1219	2.4247	-3.6435	2.0109*
Region_W	4.8116	6.2099	2.7351*	5.6885	6.1264
Region_MW	5.7276	6.2441	2.9922*	7.9378	6.1135
Region_NE	7.7677	6.1483	3.5319**	6.9950	6.0881
Region_S	5.9907	6.1430	2.8334**	5.4970	6.0917
Yr2007	-2.9245	2.5376	1.9623	-0.8806	1.2490
Yr2008	-2.8067	2.0237	1.5615*	0.1845	1.1409
Yr2009	-1.7236	2.0712	1.6191	0.1397	1.3907
Yr2010	0.4103	2.0358	1.7214	0.2355	1.4493
PercentPract	-0.0349	0.5269	0.4166	0.6342	0.3403*
Yrs_Practicing	0.0400	0.0535	0.0504	0.0039	0.0337
X_is_100	9.5418	1.7464***	2.9001***	7.4560	1.8949***
Limit_MED	-0.5673	1.5780	1.5364	-0.0553	0.8858
Limit_FIN	0.3615	1.3505	1.1902	-0.9089	0.8062
* Significant at 10%, ** Significant at 5%, *** Significant at 1%					

TABLE 7.6 – Natural Log of Patient Count Results from Experiment #3					
Dependent variable: Natural Log of Current Non-Maintenance Patients, *ln_NonMCurr*					
n = 259	**Ordinary Least Squares**			**Weighted Least Squares**	
	R^2: 0.1778	Adj. R^2: 0.0934		R^2: 0.2249	Adj. R^2: 0.1454
Independent Variable	**Parameter Estimate**	**Standard Error**	**White Standard Error**	**Parameter Estimate**	**Standard Error**
Intercept	0.4503	0.7224	0.4580	0.5832	0.4889
Sp_Addict	0.4035	0.1824**	0.1750**	0.4344	0.1721**
Sp_PCPtype	0.3388	0.1973*	0.2171	0.2627	0.1844
Sp_Anesth	-0.1905	0.4740	0.4834	-0.1001	0.4841
Sp_PainMed	0.2810	0.3256	0.4369	0.2094	0.3429
Sp_Psychiatry	0.3215	0.1945*	0.2020	0.2471	0.1815
Add_Cert	0.0349	0.1501	0.1514	0.0440	0.1373
Set_Mul	0.0763	0.2759	0.2851	0.0363	0.2660
Set_Sha	-0.6886	0.3306**	0.2255***	-0.7352	0.2526***
Set_Sin	-0.0192	0.2058	0.1988	-0.1204	0.1921
Set_Sol	-0.1376	0.1827	0.1741	-0.2210	0.1709
Set_Sta	-0.1747	0.4263	0.3233	-0.1715	0.3364
Region_W	0.2069	0.6423	0.2948	0.0729	0.3714
Region_MW	0.0789	0.6458	0.3309	0.0104	0.3958
Region_NE	0.2870	0.6359	0.3101	0.2021	0.3753
Region_S	0.2715	0.6354	0.2938	0.1401	0.3688
Yr2007	-0.2403	0.2625	0.2500	-0.1825	0.2387
Yr2008	-0.2717	0.2093	0.1944	-0.1728	0.1844
Yr2009	-0.1379	0.2142	0.2016	-0.1481	0.1934
Yr2010	-0.1098	0.2106	0.2037	-0.1360	0.2008
PercentPract	0.0957	0.0545*	0.0510*	0.1045	0.0497**
Yrs_Practicing	-0.0039	0.0055	0.0054	-0.0009	0.0052
X_is_100	0.6298	0.1806***	0.2116***	0.5810	0.1880***
Limit_MED	-0.1331	0.1632	0.1547	-0.2071	0.1464
Limit_FIN	0.0127	0.1397	0.1278	-0.0124	0.1272
* Significant at 10%, ** Significant at 5%, *** Significant at 1%					

It was also hypothesized in Section 4.5.3 that physicians in settings where costs are lower would have more non-maintenance patients. The empirical results from Table 7.6 confirm this result somewhat. Physicians who practice in a solo practice but in shared office space (*Set_Sha*) have 49.8% to 52.1% fewer non-maintenance patients than do physicians in other practice settings. This practice setting implies that costs associated with treating substance abusing patients (primarily related to the patients themselves) spill over onto other physicians, but coordination of services, economies of scale, and revenue sharing are not present. For these reasons, the costs of treating substance abusing patients may be higher for the *Set_Sha* physicians, which is why they have fewer patients.

The final hypothesis concerned those physicians who claimed addiction medicine as a primary specialty, are board certified in addiction medicine, or who dedicate a higher percentage of their practices to addiction treatment. Section 4.5.3 hypothesized that these physicians would be expected to have more non-maintenance patients. Support for this hypothesis is not overwhelming, but can be found throughout Tables 7.5 and 7.6. Starting with Table 7.5, the coefficient on *Sp_Addict* in the weighted least squares regression is positive and statistically significant, and these physicians have 3.2 more non-maintenance patients. In the same column, the estimated coefficient on *PercentPract* is also positive and statistically significant, though the magnitude of this effect is small; a 20% increase in the amount of a physician's practice that is dedicated to treating substance abuse results in 0.63 more non-maintenance patients.

Turning to Table 7.6, the *Sp_Addict* coefficient is statistically significant under all three sets of conditions, and indicates that physicians specializing in addiction medicine will have 49.7% to 54.4% more non-maintenance patients, relative to physicians not claiming this primary specialty. The *PercentPract* coefficient is also positive and statistically significant in all three cases, suggesting that a 20% increase in the amount of a physician's practice dedicated to treating substance abuse results in a 10% to 11% increase in the number of non-maintenance patients.

The OLS results in Tables 7.5 and 7.6 both suggest that psychiatrists have more non-maintenance patients than do other physicians, all else equal. Using the estimate from the natural log specification, a psychiatrist will have 37.9% more of these patients. In terms of the model, this could only be the result of lower market power or lower marginal cost. For psychiatrists, the latter is a more likely explanation. If so, these results suggest that the lower marginal opportunity costs of treating opioid dependent patients with buprenorphine is significant enough to make up for the effect of higher market power among psychiatrists.

The pain medicine specialty is statistically significant and increases the number of patients, according to the OLS results of the patient-count specification in Table 7.5. This result is not confirmed anywhere else on Table 7.5 or on Table 7.6. As discussed above with respect to psychiatrists, it could be that pain medicine specialists face lower marginal opportunity costs for providing treatment with buprenorphine than do other physicians.

Another anomalous result is the statistically significant and negative estimated coefficient on *Set_Sta* for the weighted least squares regression with the patient-count specification (Table 7.5). This result suggests that physicians in staff-model HMOs will have 3.6 fewer non-maintenance patients than physicians in other practice settings, all else equal. The model from Chapter 4 predicts that lower patient counts can be related to more market power or higher marginal costs, neither of which seems reasonable. Physicians in HMOs have essentially no market power in the sense in which it is being used here. Further, costs such as the need to find associated support services, etc., should be lower in an HMO, not higher. It could be that the marginal revenue of treating a patient for opioid dependence with buprenorphine is everywhere lower than the marginal cost (which might also be low), so that physicians in HMOs choose to withdraw no (or very few) patients. In other words, under capitation, if the patient is already a patient, treating their substance abuse delivers a marginal revenue of zero dollars.

In the OLS results of the patient-count specification (Table 7.5), many of the region-specific dummies had statistically significant coefficients only when interpreted using the White standard errors. The model provides no guidance on what the expected signs of these coefficients should be, but they are all positive, suggesting that physicians in the continental U.S. have more patients than other U.S. physicians. This result also suggests that region may be related to the heteroskedasticity observed in this sample. (See Table 6.8 for the results of the White test for heteroskedasticity.)

Similar to a result from Experiment #1, the variable for *Yr2008* was statistically significant, but only for the OLS regression of the patient-count specification, and only when interpreted using the White standard errors. Its sign is negative, indicating that these non-maintaining physicians had fewer patients in 2008 than in 2006. There is no obvious explanation for why this might have been.

The final result from Experiment #3 that deserves attention is the everywhere-statistically-significant estimated coefficient on the *X_is_100* variable in Tables 7.5 and 7.6. Using the data from Table 7.6, the results suggest that a physician that faces a caseload maximum of 100 has between 78.8% and 87.7% more non-maintenance patients than a physician that faces a caseload maximum of 30. There are two ways to interpret this result with respect to proper substance abuse treatment. On the one hand, increasing the caseload maximum causes more patients to be able to enter treatment for opioid abuse. On the other hand, many of these patients may be treated by physicians who have thus far chosen never to maintain any patients, despite the TIP's recommendations to the contrary. It is not clear what phase of treatment these additional non-maintenance patients are in. If they are in induction or stabilization, it is possible that they may be kept on a maintenance regimen as a result of the increase in the caseload maximum.

To summarize, the results of Experiment #3, which focused on the number of patients being treated by physicians who do not report having any patients on maintenance, conform somewhat to the predictions of the model of Chapter 4. There is limited evidence that physicians in primary-care type specialties treated more patients than other physicians, as predicted by the model, due to lower market power and lower opportunity costs. Physicians in solo practices in shared office space treat fewer patients than do other physicians, suggesting that the physician considers costs that spill over onto other physicians in the shared space. In Chapter 4, it was predicted that physicians who were addiction specialists would be willing to treat more patients than other physicians, and the empirical results of Experiment #3 confirm this prediction. Finally, physicians who do not maintain patients take on significantly higher numbers of patients at higher caseload maximums than they do at lower caseload maximums.

7.4 A SUMMARY OF EXPERIMENTAL RESULTS

Table 7.7 below summarizes the predicted results and actual results of all three experiments. In general, the three experiments confirm the predicted results of the model from Chapter 4.

TABLE 7.7 – Summary of Experimental Results

Experiment	**Predicted Results**	**Actual Results**
Experiment #1: This experiment explores the number of patients maintained on buprenorphine ($m = q \times y$) for physicians who report having both maintenance and non-maintenance patients, but who treat fewer total patients than the maximum allowable caseload.	Physicians in primary-care specialties will maintain more patients.	*Confirmed*. These physicians keep 14% to 15% more patients on maintenance.
	Psychiatrists will maintain fewer patients.	*Confirmed*. Psychiatrists keep 1 to 3 fewer patients on maintenance relative to other physicians.
	Physicians with attachment to addiction treatment will maintain more patients.	*Confirmed*. A one-category increase (e.g., from between 1 and 20% to between 21 and 40%) in the percentage of practice dedicated to substance abuse treatment increases the number of patients on maintenance by 9%.
	Physicians in solo practices or single-specialty group practices will keep more patients on maintenance.	*Partially confirmed*. Physicians in single-specialty group practices maintain 2 more patients than physicians in other settings. There was no statistically significant impact from solo practice setting.
	Physicians subject to higher caseload maximums will keep more patients on maintenance.	*Confirmed*. The number of patients being maintained rises by 260% when the caseload maximum rises by 233%, from 30 to 100.

TABLE 7.7 – Summary of Experimental Results, continued

Experiment	Predicted Results	Actual Results
Experiment #2: This experiment explores differences in the numbers of maintenance and non-maintenance patients after an increase in the allowable caseload maximum.	Physicians will have fewer non-maintenance patients after an increase in the caseload maximum.	*Not supported*. The intercept, though negative, does not achieve statistical significance, perhaps because an increase from 30 to 100 does not constitute a marginal change.
	Physicians will have more maintenance patients after an increase in the caseload maximum.	*Partially confirmed*. The intercept has the wrong sign but is not statistically significant. When its magnitude is compared to other positive and statistically significant results, it is clear that many physicians respond to the higher caseload maximum by increasing the number of patients on a maintenance regimen.
Experiment #3: This experiment explores the number of non-maintenance patients (*q*) by physicians who report having no patients on maintenance, but who treat fewer total patients than the maximum allowable caseload.	Physicians in primary-care specialties will have more non-maintenance patients.	*Confirmed*. Physicians in these specialties will have 40% more non-maintenance patients than physicians in other specialties.
	Physicians with attachment to addiction treatment will have more non-maintenance patients.	*Confirmed*. Physicians who declare addiction medicine as a primary specialty have 50% or more additional non-maintenance patients than other physicians.
	Physicians in solo practices or single-specialty group practices (where costs are lower) will have more non-maintenance patients.	*Partially confirmed*. Though the coefficients on these practice specialties are not significant, physicians in shared non-group office space (where opportunity costs are higher) have 50% fewer non-maintenance patients relative to physicians in other settings.
	Physicians subject to higher caseload maximums will have more non-maintenance patients.	*Confirmed*. The number of non-maintenance patients rises by 79 - 88% when the caseload maximum rises from 30 to 100.

CHAPTER 8: CONCLUSIONS

8.1 INTERPRETATION OF RESULTS

Three experiments were performed in Chapter 7: one on the number of maintenance patients (Experiment #1), one on the number of non-maintenance patients (Experiment #3), and one on the differences in the numbers of patients of both types after a change in the caseload maximum (Experiment #2). Non-maintenance patients include new patients in the induction and stabilization phases of treatment as well as patients being withdrawn from buprenorphine. In general, the results of the three experiments confirm the predictions of the algebraic model that was presented in Chapter 4.

Physician specialty appears to reveal much about physician market power and opportunity costs. Physicians in primary-care-type specialties (like internal medicine, family medicine and pediatrics) treat more patients than do physicians in other specialties. The results of Experiment #1 suggest that physicians in these specialties maintain 14% to 15% more patients than do other physicians (see Table 7.2); the results of Experiment #3 suggest that these physicians have 40% more non-maintenance patients than do other physicians (see Table 7.6). The physicians in the sample for Experiment #1 also had non-maintenance patients, but the physicians in Experiment #3 did not have any patients on maintenance, so the difference in the magnitudes of these effects cannot be interpreted. Experiment #2 explored changes in patient counts as a result of changes in the caseload maximum, and its results confirmed that physicians in primary-care-type specialties will increase the number of patients of both types in response to an increase in the caseload maximum. For these physicians, the increase in maintenance patients is thrice the increase in non-maintenance patients.

Physicians with professional attachment to addiction treatment treat more patients than do other physicians, likely because they face lower opportunity costs. Professional attachment to addiction treatment is demonstrated in the survey data by certification in addiction medicine, by the choice of addiction medicine as a primary specialty, or by the percentage of a physician's practice dedicated to treating patients for substance abuse. In Experiment #1, only the percentage of practice dedicated to treating substance abuse has a significant effect on the number of patients on maintenance. The results of Experiment #3 suggest that physicians who declare addiction medicine as a primary specialty have 50% more non-maintenance patients than physicians who do not (see Table 7.6).

Practice setting appears to reveal less about market power and opportunity cost, so there are only limited results that link practice setting to physician treatment choices. The results from Experiment #3 suggest that for physicians who do not report having any patients on maintenance treatment, practice settings such as a solo practice in a shared office space and staff-model HMO are both negatively related to the number of patients treated. It could be that lack of economies of scale in solo practices, combined with the potential for costs to spill over, lead these physicians to treat fewer patients. Physicians in HMOs may be subject to payment by capitation, whereby treating current patients for their addictions may not generate any marginal revenue. Practice setting is a complicated variable. The possibilities for economies of scale, cost sharing, revenue sharing, and access to physicians in related specialties all suggest that in order for the impact of practice setting to be fully explored, the model may have to be extended to include these specific elements.

The most important results from the experiments in Chapter 7 relate to the impact of the caseload maximum on the number of maintenance patients (Experiment #1) and non-maintenance patients (Experiment #3). In all regression specifications, the dummy variable indicating that the physician faced a higher caseload maximum, *X_is_100*, was positive and statistically significant. Specifically, all three experiments confirm that the incidence of maintenance treatment rises as the caseload maximum increases.

Physicians with excess treatment capacity (with respect to the federal caseload maximum) and patients of both types (Experiment #1) will increase the number of patients on maintenance by 2.5 times when the caseload maximum increases by 2.33 times. This means that in response to the caseload maximum, these physicians either reduce their excess capacity to maintain more patients, or they have fewer non-maintenance patients. The empirical results from Experiment #3 on non-maintenance patients show that physicians who choose not to maintain patients also increase the number of patients they treat in response to an increase in the caseload maximum, but they increase this number proportionately less.

The results of the difference-in-maintenance regressions in Experiment #2 (see Table 7.4) also confirm this result. Though the intercept is negative, it is not statistically significant. Further, many of the other coefficients are positive and greater in magnitude (especially when combined) than the negative intercept. Physicians in primary-care type specialties and with the average number of years of experience will maintain nearly 40 more patients after the increase in the caseload maximum (or about 18 more after considering the negative intercept).

8.2 LIMITATIONS AND EXTENSIONS

This study is subject to several limitations in addition to low numbers of observations for Experiment #2 (75) and Experiment #3 (259). First, it made use of data that were originally collected for an entirely different purpose. Though the data yielded compelling results, a survey instrument specifically designed for the purposes of this study might have resulted in richer results. The survey data allowed for a distinction between the number of maintenance patients and the number of non-maintenance patients but did not include any measure of visit count or visit intensity in either case. In general, induction and stabilization require more, and more frequent, visits than does maintenance, but physicians may differ in the number of visits they require during these early phases of treatment, as well as the intensity of those visits with respect to tests and other services ordered. Visit frequency and visit intensity in maintenance is subject perhaps to even wider variation. The empirical model necessarily treats all “non-maintenance” patients alike and all “maintenance” patients alike, but in practice, physicians may vary in their ability and willingness to induce more or fewer (or more intense or less intense) visits. The algebraic model implicitly assumed that all non-maintenance patients were in the induction and stabilization phases of treatment, but they could also have been in the dose reduction phase.

The model also does not consider patient expectations over treatment, but treats the decision about maintenance as solely the physician’s decision. While this is approximately the case, in order to explore the role of demand inducement in treatment with buprenorphine, it would be necessary to have patient-level data that revealed what patients wanted from treatment. The substance abuse treatment community has formed a consensus with respect to the proper use of buprenorphine, but it is not clear how well patient goals or expectations align with these treatment protocols.

The analysis also ignores any potential impact of third-party payment, whether by private medical insurance or public assistance such as block grants. Because financial considerations appear to play some role in the physician’s decision to prescribe buprenorphine (and for what purpose to prescribe it) these missing data may limit the proper interpretation of the results of Chapter 7.

The data used in the empirical work of Chapters 6 and 7 contain physician-level data about current caseloads. It does not allow for the calculation of 1) the rate at which induction or stabilization is successful, 2) the rate at which successfully-stabilized patients are maintained on buprenorphine or 3) the rate at which maintenance patients are eventually withdrawn. If physicians inexperienced with buprenorphine have lower success rates in induction and stabilization, then their pools of potential maintenance patients are likewise smaller. Over time (or during the one year that elapses between first and second DEA notifications), inexperienced physicians may make marginally greater strides in their success rates, causing the empirical results to overestimate the effect of physician specialty on responses to the caseload maximum.

The final, and perhaps most important, limitation of the study is the fact that the data did not include an exact record of the caseload maximum faced by the physician at the time of the observation. The current caseload maximum had to be imputed. Though the imputation was rigorous, it would have been preferable to have physician-reported data to ensure that this variable was not miscoded. Given the imputation and sample creation methods discussed in Chapter 6, it is more likely that some physicians who actually faced only 30-patient caseload maximums were misidentified as physicians who faced 100-patient caseload maximums. In this case, it is possible that the analysis in Chapter 7 underestimates the true impact of the increase in the federal caseload maximum.

In addition to addressing the limitations noted above, the analysis of the preceding chapters could be extended. Over time, more observations will become available, allowing Experiments #2 and #3 to be repeated. Higher numbers of observations could also allow for an increase in the number of independent variables (and interaction terms) included in the regressions. This could allow for more detailed analysis of the differential impact of caseload maximums on physicians in different specialties, different settings, or different specialty/setting combinations.

The model presented in Chapter 4 assumed that the physician was able to induce demand for maintenance treatment (in either a positive or negative direction). The model could be extended with the formulation of a non-inducement companion model. The comparative statics results of the two models could be compared to each other—and also to the empirical results—to perform tests on the null hypothesis of no demand inducement in the spirit of Schaafsma (1994). In this way, the analysis performed here could contribute to the literature on supplier-induced demand by providing another unique test.

The model was also only a two-period model, eliminating the possibility of maintenance-then-withdrawal as a possible treatment path. The model could be extended either to a three period model or an infinite-time-horizon model. An extended model of this type could take advantage of the ability to separate in the data “new” patients (in induction or stabilization) from “withdrawal” patients (those in dose reduction).

8.3 SUMMARY

The results of this study, presented in the last chapter, support the conclusion that many factors other than recommended treatment protocols may enter into physician decision-making. Federal caseload maximums have a clear impact on both the volume of treatment for opioid dependence as well as the nature of this treatment. Increased federal caseload maximums lead to an increase of patients maintained on buprenorphine that is disproportionately greater than the increase in total patient counts.

The physician's specialty and professional attachment to substance abuse treatment also influence the choice of treatment path. Physicians in specialties with lower opportunity costs and less market power (such as internal medicine, family medicine or pediatrics) treat more patients at any given federal caseload maximum than do physicians in other specialties. Though these physicians respond to increased federal caseload maximums by having both more maintenance patients and more non-maintenance patients, they add about three patients to their maintenance caseload for every one additional non-maintenance patient. Psychiatrists appear to maintain fewer patients (Table 7.1) and have more non-maintenance patients (Tables 7.5 and 7.6) than do physicians in other specialties, but they respond to an increase in the caseload maximum by disproportionately increasing the number of patients they keep on maintenance (Tables 7.3 and 7.4). As should be expected, physicians with professional attachment to substance abuse treatment (demonstrated by board certification, primary specialty, or percentage of practice dedicated to substance abuse treatment) treat more patients of both types than do other physicians.

Policymakers should bear in mind that restrictions placed on physicians—such as the federal caseload maximum for waivered physicians using buprenorphine to treat opioid dependence—can have significant impacts on the treatment decisions made by physicians. Physicians are not homogenous. Specialty, practice setting, board certification, years of experience and other variables are all related to the physician's treatment choice. This is true even with respect to conditions for which there is considerable consensus in the research and academic communities regarding treatment. Even in the face of strong and consistent support for medication-assisted maintenance treatment of opioid dependence, and recommended protocols and training that endorse the same, many physicians still offer limited maintenance treatment. This could be the result of ideology, but this study supports the notion that economic considerations also enter into physician decision-making.

APPENDIX A: THE PHYSICIAN SURVEY

PHYSICIAN SURVEY, TEXT OF SELECTED QUESTIONS, Version 4/1/05

1. What do you consider to be your primary specialty? (Mark no more than three)

- Addictions
- Allergy
- Anesthesiology
- Cardiology
- Community Health
- Dermatology
- Emergency Medicine
- Endocrinology
- Family Medicine
- Gastroenterology
- Immunology
- Internal Medicine
- Neurology
- Ob-Gyn
- Occupational Medicine
- Oncology
- Pain Medicine
- Pediatrics
- Psychiatry

- Pulmonary Medicine
- Rehabilitation Medicine
- Surgery
- Other Specialty

2. How many years have you been licensed to practice medicine, in any state?

    ____ Years of practice

3. Mark any of these certifications in addiction medicine that you currently hold.

- American Board of Medical Specialties
- American Society of Addiction Medicine
- American Osteopathic Association
- Not certified in addiction medicine

4. Which of these best describes your current practice? If you are involved in more than one practice, select the one where you are most likely to care for substance abusing patients. (Select only one)

- Solo practice
- Solo practice, space shared with other physicians
- Single specialty group practice
- Multispecialty group practice
- Hospital-owned practice
- Staff model HMO
- Other type of practice

6. On which date are you filling out this section of the survey?

________ / ________ / ________

Month Day Year

9. What percentage of your total medical practice during this period would you estimate was devoted to treating substance abuse patients?

- 0%
- 1 - 20%
- 21 - 40%
- 41 - 60%
- 61 - 80%
- 81 - 100%

11. Within the past 90 days, how many patients have you treated with buprenorphine for opioid dependence? Count all patients, regardless of whether or not you are seeing them under a CSAT Waiver?

________ Buprenorphine patients

12. How many patients are you currently treating with Suboxone and Subutex for opioid dependence? Count all patients, regardless of whether or not you are seeing them under a CSAT Waiver?

________ Suboxone ________ Subutex

13. How many of these patients currently on Suboxone or Subutex are on maintenance and how many are on a withdrawal regimen?

________ Maint. ________ Wdwl.

14. What do you think are the limitations associated with buprenorphine maintenance treatment? (Mark no more than three)

- Titration of dose is difficult/time consuming
- High cost
- Inadequate third-party reimbursement
- Low patient acceptance or interest
- Limited effectiveness
- Likelihood of adverse events
- Medical complications
- Difficulty accessing counseling or other services
- Lack of pharmacies carrying buprenorphine
- Diversion risk
- Federal patient limit
- Recordkeeping requirements
- Concern about DEA involvement
- Other ______________________ Specify (print)

15. In the past 90 days, how many individuals did you turn down for buprenorphine treatment because of the federal limit on physicians' buprenorphine caseloads?

________ Patients turned down

PHYSICIAN SURVEY, TEXT OF SELECTED QUESTIONS, Version 4/7/08

1. What do you consider to be your primary specialty? (Mark no more than three)

- Addictions

- Allergy
- Anesthesiology
- Cardiology
- Community Health
- Dermatology
- Emergency Medicine
- Endocrinology
- Family Medicine
- Gastroenterology
- Immunology
- Internal Medicine
- Neurology
- Ob-Gyn
- Occupational Medicine
- Oncology
- Pain Medicine
- Pediatrics
- Psychiatry
- Pulmonary Medicine
- Rehabilitation Medicine
- Surgery
- Other Specialty

2. How many years have you been licensed to practice medicine, in any state?

____ Years of practice

3. Mark any of these certifications in addiction medicine that you currently hold.

- American Board of Medical Specialties
- American Society of Addiction Medicine
- American Osteopathic Association
- Not certified in addiction medicine

4. Which of these best describes your current practice? If you are involved in more than one practice, select the one where you are most likely to care for substance abusing patients. (Select only one)

- Solo practice
- Solo practice, space shared with other physicians
- Single specialty group practice
- Multispecialty group practice
- Hospital-owned practice
- Staff model HMO
- Other type of practice

5. How long have you been certified to prescribe buprenorphine for the treatment of opioid dependence?

- Less than 1 year
- 1 - 2 years
- 3 - 4 years

- More than 4 years

8. On which date are you filling out this section of the survey?

________ / ________ / ________

Month Day Year

11. What percentage of your total medical practice during this period would you estimate was devoted to treating substance abuse patients?

- 0%
- 1 - 20%
- 21 - 40%
- 41 - 60%
- 61 - 80%
- 81 - 100%

13. Within the past 90 days, how many patients have you treated with buprenorphine for opioid dependence? Count all patients, regardless of where you saw them.

________ Buprenorphine patients

14. How many patients are you currently treating with Suboxone and Subutex for opioid dependence? Count all patients, regardless of where you see them.

________ Suboxone ________ Subutex

Note— In answering questions 15 and 16, be sure the total number of patients reported always equals the total patients on Suboxone and Subutex reported in question 14.

16. How many of your patients, in all settings, are in the following phases of buprenorphine treatment?

________ Induction ________ Maintenance ________ Dose tapering

19. In the past 90 days, how many individuals did you turn down for buprenorphine treatment because of the federal limit on physicians' buprenorphine caseloads?

________ Patients turned down

20. What do you think are the limitations associated with buprenorphine maintenance treatment? (Mark no more than three)

- Titration of dose is difficult/time consuming
- High cost
- Inadequate third-party reimbursement
- Low patient acceptance or interest
- Limited effectiveness
- Likelihood of adverse events
- Medical complications
- Difficulty accessing counseling or other services
- Lack of pharmacies carrying buprenorphine
- Diversion risk
- Federal patient limit
- Recordkeeping requirements
- Concern about DEA involvement
- Other ______________________ Specify (print)

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ABSTRACT

THE IMPACT OF REGULATORY CHANGES ON THE PROVIDERS OF TREATMENT FOR OPIOID DEPENDENCE

by

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Major: Economics

Degree: Doctor of Philosophy

In 2000, changes in federal law allowed physicians to receive waivers to use narcotic medications, such as buprenorphine, for treatment of opioid dependence. As of 2006, physicians have been allowed to treat up to 100 patients after spending one year at a 30-patient limit. Physicians may choose to discontinue use of buprenorphine after the patient has successfully discontinued use of the substance of abuse ("withdrawal"), or physicians can keep patients on buprenorphine indefinitely ("maintenance"). The model in this dissertation assumes that demand for treatment of opioid dependence is exogenous but that demand for maintenance treatment can be induced by the physician. Using data from quarterly surveys of physicians from 2006 to 2010, this dissertation analyzes the impact of the higher caseload limit on the number of patients and the treatment path chosen by the physician. It finds support for the conclusion that physicians treat more patients after an increase in the caseload limit. The impact is particularly strong for maintenance, suggesting that the caseload limit discourages maintenance treatment. The dissertation also finds that this effect is stronger for physicians in primary-care type specialties.

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