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Abstract

Medical malpractice liability reform is often promoted as a means to increase the labor supply of health care providers and improve access to medical care. Theory suggests, however, that if physicians differ in their malpractice risk, then reforms will tend to attract those physicians with the highest risk. In principle, any association between reforms and overall malpractice risk could be attributable to adverse selection or moral hazard. This paper uses the location and relocation choices of physicians to disentangle these two competing behavioral effects. If moral hazard dominates, only the current practice location should matter, while if there is adverse selection, then the location and relocation history should signal risk. Using data on physicians with multiple malpractice events, the paper shows that relocation history is correlated with risk. Moreover, relocation history appears to predict risk better than current location. Taken together, these results imply that adverse selection occurs and is a comparatively more important behavioral effect than moral hazard.

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I. Introduction

During the medical malpractice "crisis" of the early 2000s, there were numerous demonstrations and work stoppages staged by physicians to protest rising insurance premiums.[1] Events such as these helped stoke public concern that the costs associated malpractice liability were driving up health care costs and even driving some physicians out of practice. Such concerns have been used to promote the adoption of new malpractice reforms, such as the adoption of a nationwide cap on noneconomic damage awards. While insurance premiums appear to have stabilized in recent years, the emphasis on health care reform under President Obama has renewed calls for tort reform as part of the overall package.[2] At the state level, medical malpractice is already subject to more kinds of reforms restricting liability than any other area of civil litigation.

Malpractice reform proposals often meet fierce opposition, particularly from attorney organizations and consumer advocates. One argument that is often used against liability reform is the idea that it could increase the risk to patients. This can happen because a reduction in expected liability costs reduces the incentives of physicians to take precaution and increases patient exposure to negligence. Another mechanism through which liability reform could increase patient risk is by attracting higher risk physicians to practice in the area. If physicians

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[1] For example, in January of 2003 nearly 40 surgeons in West Virginia walked off the job. For more information see "W. VA. Doctors Strike Over Insurance Costs," CNN.com/Health, available at http://www.cnn.com/2003/HEALTH/01/01/medical.malpractice/ (accessed May 2009).

[2] See "AMA Commits to Help Slow Increases in Health Spending," at http://www.ama-assn.org/ama/pub/news-events/news-events/health-spending.shtml (accessed May 13, 2009). Texas Governor Rick Perry claimed that the reforms in Texas generated a 57% increase in the number of applications to practice medicine in Texas (see "Gov. Rick Perry: Tort reform must be part of health care reform", Op-ed, Washington Examiner, August 13, 2009, at http://www.washingtonexaminer.com/opinion/columns/OpEd-Contributor/Tort-reform-must-be-part-of-health-care-reform-8096175.html,accessed September 3, 2009). Former Alaska Governor Sarah Palin supported this position, advocating the inclusion of tort reform in a national reform package (see "Palin: Can't have health care reform without medical malpractice reform", Washington Examiner, August 21, 2009, at http://www.washingtonexaminer.com/opinion/blogs/beltway-confidential/Palin-Cant-have-health-care-reform-without-medical-malpractice-reform-53949082.html, accessed September 3, 2009).

differ according to their malpractice risk, then we might expect that high risk physicians will be more likely to gravitate to an area that adopts reform. The former behavioral mechanism represents moral hazard on the part of physicians, while the latter represents adverse selection. In principle either of these two mechanisms has the same net effect of increasing the amount of malpractice after the adoption of reform, but the distinction has important behavioral and policy implications.

This paper uses the location and relocation decisions of physicians to disentangle the effects of medical malpractice liability reform on risk to patients. Physicians in lower malpractice cost environments have fewer incentives to take precautions to avoid negligence and they could have been drawn to these areas because they have intrinsically higher risk and place greater value on the lower costs. Both effects will generate a positive correlation between reform and risk, and neither is mutually exclusive of the other. This paper demonstrates that in the absence of adverse selection, relocation (or the lack thereof) should be uncorrelated with physicians' malpractice risk. That is, in the "pure" moral hazard model, only the current location should have any predictive information about risk. Thus, we can test for the existence of adverse selection by testing for the correlation of *past* location choices and future risk conditional on *current* location.

The paper implements this test using state malpractice reforms and data on malpractice payments from the National Practitioner Data Base (NPDB). The NPDB is a national repository of paid malpractice claims with mandatory reporting in operation since 1991. The NPDB tracks individual physicians over time but it is not a true panel because physicians only appear when they experience a recordable malpractice event. Information is recorded on practice locations at the time of an event, which does allow for an analysis of location and relocation conditional on an event. The NPDB is combined with data on state tort reform and other demographics to estimate the relationship between expected malpractice costs and the location. Specifically, tests are conducted as to whether or not physicians with higher risk, as measured by the number of malpractice claims in the NPDB, are more likely to practice in states with lower expected malpractice costs.

The empirical results confirm that tort reforms are associated with higher malpractice risk: physicians who practice in an area with reform at the time of the first event appear more likely to experience future malpractice events. For example, physicians found in states with a "high intensity" malpractice reform environment are approximately 5% more likely to experience future malpractice events. The results also suggest that adverse selection appears to be the dominant factor in explaining this relationship. The initial choice of location to either a tort reform or non-tort reform state appears to be a more important predictor of risk than simply being in a tort reform state, consistent with a model of adverse selection. While this result does not rule out the possibility of moral hazard associated with tort reform, it does suggest that any such effect is of secondary importance in terms of its effect on patient risk.

These findings have important implications for the welfare consequences of tort reform. If adverse selection is the dominant behavioral effect, then the adoption of a nationwide tort reform policy should have little impact on the aggregate risk to patients. This is due to the fact that, in the absence of a strong moral hazard effect associated with malpractice liability, tort reform will only affect the reallocation of physicians to different areas. In addition, the existence of adverse selection potentially offers support for a policy mandating the nationwide disclosure of malpractice history to patients.

The paper proceeds as follows: Section II describes the related literature on the behavioral effects of medical malpractice liability. Section III develops the conceptual model of malpractice risk and practice location and relocation decisions by physicians. This model illustrates how location choices allow us to disentangle adverse selection and moral hazard. Section IV describes the data and outlines the empirical specifications. Section V presents the results. The paper concludes with a discussion of the welfare and policy implications of the findings.

II. Related Literature

There is an extensive literature on the behavioral effects of medical malpractice on health care providers, though it has generally not focused on the distinction between moral hazard and adverse selection. Much of the literature focuses on the impact of malpractice liability on the propensity of physicians to intensify treatment, i.e. to practice "defensive medicine." The seminal paper on defensive medicine by Kessler and McClellan (1996) uses the adoption of state tort reform as a shock to malpractice costs and identify an increase in the treatment costs of heart attack patients (findings that were confirmed in Kessler and McClellan (2002a) and Kessler and McClellan (2002b)). Others extended the analysis to consider the impact of malpractice in obstetrics (c.f., Currie and MaCleod, 2004; Tussing, Wojtowycz et al. (1994); Corrigan, Wagner et al. (1996); Dubay, Kaestner et al. (1999); Dubay, Kaestner et al. (2001)). Studies focusing on more general medical procedures include Bovbjerg, Dubay et al. (1996), Baicker and Chandra (2006), Baicker and Chandra (2007) and Lakdawalla and Seabury (2009).

A different strand of the literature is concerned with the impact of malpractice on the access to care, specifically through the labor supply decisions of physicians. Kessler, Sage et al. (2005) and Hellinger and Encinosa (2006) find that the adoption of malpractice liability reform leads to a small but statistically significant increase in the supply of physicians in a state. Klick and Stratmann (2007) find that the effect of tort reform seems to be driven by the response of physicians in high malpractice risk specialties to the presence of noneconomic caps. Baicker and Chandra (2006) and Matsa (2007) find that malpractice liability appears to have a greater effect on physician supply to rural areas. These studies focus primarily on the extensive margin of physician supply (at least in a given area). Helland and Showalter (2006) use data on hours worked by physicians and find that malpractice liability has a stronger effect on the intensive margin. The literature generally does not consider how the labor supply decisions of physicians differ according to individual differences in malpractice risk.

One reason that past studies have paid little attention to the possibility that tort reform attracts high risk doctors is a common perception that the malpractice system does a poor job at identifying negligent care. Numerous studies have argued that there is a weak correlation between malpractice claims and negligence (Weiler et. al., 1993; Thomas et. al., 2000; Studdert et. al., 2000; and Thomas et. al., 2002). There does appear to be a clear link, however, between a malpractice payment and negligence, at least in the sense that a majority of paid malpractice claims appear to involve negligence (Studdert et. al., 2006). Furthermore, past work suggests that physicians are heterogeneous in their risk of experiencing malpractice events (Gibbons et. al., 1994). In terms of the implications for the behavior of physicians, if physicians are heterogeneous in the risk of actually *committing* malpractice or only in being *accused* of malpractice then adverse selection could still result. As long as physicians know that they differ in their expected malpractice costs then their behavioral responses to malpractice risk will differ accordingly.

III. Theoretical Framework

Model setup

Consider a model in which physicians are hired by hospitals to provide treatment to patients.[3] Each physician *i* has a fixed marginal product that is given by θ_i. There are two types, high and low productivity denoted $\overline{\theta}$ and $\underline{\theta}$, respectively. The fraction of high productivity physicians is given by μ, where $\Pr\left(\theta_i = \overline{\theta}\right) = 1 - \Pr\left(\theta_i = \underline{\theta}\right) = \mu$. While θ is observable to the physician, however, it is assumed to be unobservable to hospitals. Thus, a hospital's wage offer for an individual physician is based on the hospital's beliefs about that physician's marginal productivity. For simplicity, all physicians are assumed to treat the same number of patients in all periods.[4]

In any given time period, each physician faces the risk of a malpractice claim filed by a patient. The probability of a malpractice claim against physician *i* for all treatments in a given period is given by $q(x_i)$, where x represents the level of risky care that a physician provides. High risk care could be negligent care or it could possibly reflect other factors, such as accepting higher risk patients.[5] Regardless of the cause, providing riskier care increases the likelihood of a claim. For simplicity assume that $q(x_i) = x_i$. If physicians wish to reduce the level of risky care they provide, they must bear the opportunity cost (essentially the cost of precaution) given

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[3] Physicians are usually not employed directly by hospitals in the traditional sense. For the model, it does not matter if physicians contract with hospitals or directly with patients as long all patients have identical information. Hospitals are used as the contractual entity merely to provide additional expositional clarity.

[4] In practice, differences in the number and composition of patients treated could lead to variation in malpractice risk. For our purposes, all such differences are subsumed into differences in physician type.

[5] In practice, different physicians will have different levels of risk based on specialty (e.g., surgery carries higher risk than internal medicine). We abstract from these kinds of differences to focus on how risk differs across physicians based on their behavior.

by $V(x_i, \theta_i)$, where $V_x > 0$ and $V_{xx} < 0$. Assume that physicians with higher marginal product face a lower opportunity cost, i.e., $V_{x\theta} < 0$.

Each malpractice claim comes with a geographically-specific cost, driven by exogenous factors such as tort reform. Physicians choose their practice locations, implying that malpractice cost conditional on a claim, denoted *c*, is a choice variable for physicians.[6] In order to lower malpractice cost, however, physicians bear an opportunity cost of moving, denoted τ. This cost, which we refer to as the "relocation cost," can be positive or negative. Therefore, in some cases physicians actually benefit from moving. We assume that transaction costs are randomly distributed across physicians and are unobservable by hospitals, though hospitals know the distribution. We also assume that the distribution of relocation costs satisfies the monotone likelihood ratio property (MLRP).[7] Finally, we also assume that relocation costs are independent of physician type, which is reasonable if we think of variation in relocation costs as being driven by non-professional factors such as family-level location preferences.[8]

Assuming risk neutral physicians, the expected utility function of physician *i* in time *t* is given by:

$$E_t\left[U_{it} \mid \theta\right] = \hat{\theta}_{it} - x_{it}c_{it} + V(x_{it}, \theta_i) + \tau_{it}\, c_{it}$$

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[6] If malpractice costs were fully insurable, this would mute the impact of geographic-specific malpractice cost on the level of risk. The portion of malpractice costs that is uninsured is generally considered to be substantial (Kessler and McClellan, 2002b; Currie and MacLeod, 2008). The predictions of the model are identical if we think of *c* as representing geographic-specific variation in expected uninsured costs of malpractice claims.

[77] If $f(x \mid y)$ is the probability density of *x* conditional on *y*, satisfaction of the MLRP implies $\frac{\partial}{\partial x}\left(\frac{f(x \mid y_1)}{f(x \mid y_2)}\right) \geq 0$ for all *x* and $y_1 > y_2$.

[8] Making relocation costs unobservable generates noise in the signal, which in the analysis that follows will prevent hospitals from fully inferring physician type from their observed behavior, i.e., it rules out a fully separating equilibrium.

where $\hat{\theta}_{it}$ represents the hospitals' expectation about the physician's type. While relocation costs are distributed randomly, we assume they are realized before physicians choose their location. Thus, the expected utility function is evaluated after relocation costs are realized but before malpractice claims are.

The labor market for physicians is assumed to be competitive, with both hospitals and physicians acting as price takers.[9] This implies an equilibrium condition for the physician labor market requiring that each physician's wage offer is equal to their expected marginal productivity given all publicly available information about the physician, i.e., $\hat{\theta}_{it} = E_t[\theta_i]$. This condition requires that the equilibrium wage offer be equal to $\hat{\theta}_{it} = \hat{\mu}_{it}\overline{\theta} + (1-\hat{\mu}_{it})\underline{\theta}$, where $\hat{\mu}_{it}$ is the conditional probability that physician *i* has high productivity. The formation of beliefs is driven by what hospitals observe about physicians' location choices and malpractice histories.

Practice location and malpractice risk in a static model

First consider a static model, in which physicians make a single location choice and practice medicine without any observed malpractice history. Hospitals cannot observe θ, nor can they observe x. They do observe practice location, however, providing them with a signal of physician type. The probability that a physician is the high productivity type conditional on location choice is:

[9] There is debate in the literature about whether or not hospitals act similarly to profit maximizing firms (see Newhouse, 1970; Glaeser and Schleifer, 2001; Lakdawalla and Phillipson, 2006). This debate is beyond the scope of this paper, but if a significant portion of physician wages are driven by returns to general (as opposed to industry-specific) human capital, or if at least a significant fraction of hospitals in the market act rationally, then wages will be set equal to marginal product as in a competitive market. For physicians, self-employment would seem to provide a viable outside opportunity to any noncompetitive behavior by hospitals (or practice groups).

$$\hat{\mu}\left(c_i^*\right)=\frac{\mu}{\mu+(1-\mu)\dfrac{\Pr\left(c_i=c_i^*\mid\underline{\theta}\right)}{\Pr\left(c_i=c_i^*\mid\overline{\theta}\right)}}$$

Hospitals incorporate this belief about the productivity of physician *i* and offer wage $\hat{\theta}_i$.

Physicians choose the optimal levels of *x* and *c,* denoted x^* and c^* respectively, to maximize expected utility given the relationship between location choice and wage. The optimal choices are defined by the following first order conditions for *x* and *c* (omitting subscripts):

$$V_x(x,\theta)-c=0$$

$$\frac{\partial\hat{\theta}}{\partial c}+\tau-x=0$$

The first condition requires that physicians balance the marginal cost of precaution against the expected increase in malpractice cost. The second requires that they balance the effect of relocation on wages against the net gain of lower malpractice cost over the relocation cost.

Using the assumptions made on $V(x,\theta)$ and the distribution of *τ*, we observe the following properties of the equilibrium location and risk choices:[10]

- *All physicians take fewer risks in high cost areas:* $x^*(\theta,\underline{c})\geq x^*(\theta,\overline{c})$ for $\overline{c}>\underline{c}$
- *Type* $\underline{\theta}$ *physicians take more risks:* $x^*(\underline{\theta},c)\geq x^*(\overline{\theta},c)$ for all *c*
- *Type* $\underline{\theta}$ *physicians choose lower malpractice costs:* $c^*(\underline{\theta})\geq c^*(\overline{\theta})$

The first two relationships simply highlight the existence of moral hazard, and note that it is stronger among the low productivity physicians. The third relationship indicates that there is

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[10] The assumptions made on $V(x,\theta)$ directly imply that low productivity physicians provide higher risk care, and thus have greater incentives to relocate, so $\frac{\partial x^*}{\partial\theta}<0$. The first order condition for *c* suggests $\Pr\left(c=c^*\mid\theta\right)=\Pr\left(-\tau=\frac{\partial\hat{\theta}}{\partial c}-x^*(\theta)\right)$. Incorporating these into $\hat{\mu}\left(c_i^*\right)$ applying the MLRP implies that $\frac{\partial\hat{\theta}}{\partial c}\geq 0$.

adverse selection, with low productivity, high risk physicians migrating to areas with lower malpractice costs. Intuitively, this result is driven by the fact that the low productivity physicians always have more incentives to provide risky care than the high productivity physicians. Thus, they receive greater expected benefits from the savings associated with being in a low cost area, and are more likely to select a lower c for any given value of relocation costs.[11]

While these results indicate that practice location is correlated with underlying physician risk, they also highlight the challenge in separately identifying adverse selection and moral hazard. Even if we observe variation in both c and x and find a negative correlation, this could be due to either behavioral effect. In the dynamic model, however, we show that historical location choices can be used to separately identify the two.

Malpractice history and location choice in a dynamic model

In a dynamic model, hospitals observe whether physicians experience malpractice claims in each period, providing them with additional signals of physician type. Let H_{it} denote an index of malpractice claims and location choices for physician i for all periods prior to time t. Here the conditional probability in time t that physician i is a high productivity physician is given by:

[11] In order to guarantee a single, unique solution, we must also ensure satisfaction of the second order condition for c (the second order condition for x holds unambiguously). Satisfaction of the second order condition for c requires that $\frac{\partial^2 \hat{\theta}}{\partial c^2} \geq 0$. Let the function $h(c)$ represent the likelihood ratio $\frac{\Pr\left(c_i = c_i^* \mid \underline{\theta}\right)}{\Pr\left(c_i = c_i^* \mid \overline{\theta}\right)}$. The second order condition holds if $\frac{\partial^2 h / \partial c^2}{\left(\partial h / \partial c\right)^2} \geq \frac{2(1-\mu)}{\mu + (1-\mu)h}$. This condition appears to be satisfied in most commonly used distribution functions satisfying the MLRP (e.g., the normal distribution or exponential distributions) as long as the fraction of low productivity physicians is sufficiently low.

$$\hat{\mu}\left(c_i^*, H_{it}\right) = \frac{\mu}{\mu + (1-\mu)\dfrac{\Pr\left(c_i = c_i^* \mid \underline{\theta}, H_{it}\right)\Pr\left(H_{it} \mid \underline{\theta}\right)}{\Pr\left(c_i = c_i^* \mid \overline{\theta}, H_{it}\right)\Pr\left(H_{it} \mid \overline{\theta}\right)}}$$

Thus, each period the wage offer $\hat{\theta}_{it}$ is updated to reflect any new information provided by the physician's current and past location choices and past malpractice outcomes.

In the dynamic model, physicians choose risk and location to maximize expected utility in current and future periods. Physicians choose x_t and c_t to solve (omitting subscripts for physicians):

$$\max_{x_t, c_t} \quad \hat{\theta}(c_t, H_t) + V(x_t, \theta) - x_t c_t + \tau_t c_t$$
$$+ \beta E_t\left[\hat{\theta}(c_{t+1}, H_{t+1}) + V(x_{t+1}, \theta) - x_{t+1}c_{t+1} + \tau_{t+1}c_{t+1} + \beta E_{t+1}\left[U_{t+2}\right]\right]$$

where β is the discount rate and U_{t+2} represents the expected utility of a physician in time $t+2$. Note that a new value of τ is realized in each period, leading to (potentially) new location choices. Applying the law of iterated expectations and the envelope theorem, the first order conditions for a solution with respect to x and c, respectively, are:

$$V_x(x_t, \theta) - c_t + \beta \frac{\partial}{\partial x_t} E_t\left[\hat{\theta}_t + \sum_{n=1}^{N} \beta^n \hat{\theta}_{t+n}\right] = 0$$

$$\frac{\partial \hat{\theta}_t}{\partial c_t} + \tau - x + \beta \frac{\partial}{\partial c_t} E_t\left[\hat{\theta}_t + \sum_{n=1}^{N} \beta^n \hat{\theta}_{t+n}\right] = 0$$

where $N+1$ represents the total number of future periods over which the physician is maximizing.

Equilibrium in the dynamic model is similar to that in the static model, except that physicians incorporate the impact their decisions will have on earnings in future periods. Choosing higher levels of risk in the current period increases the likelihood of a malpractice claim, lowering in future periods the expected belief that the physician has high productivity, i.e.,

$\frac{\partial \hat{\theta}_{t+n}}{\partial x_t} \leq 0$ for all $n = 1,...,N$. Conversely, bearing a high malpractice cost makes physicians appear lower risk now and in the future, i.e., $\frac{\partial \hat{\theta}_{t+n}}{\partial c_t} \geq 0$ for all $n = 1,...,N$.[12]

These changes to the equilibrium conditions do not alter the underlying prediction that $x^*(\theta, \underline{c}) \geq x^*(\theta, \bar{c})$ and $c^*(\underline{\theta}) \geq c^*(\bar{\theta})$. Moreover, the dynamic model provides additional information to distinguish between moral hazard and adverse selection. If physicians are homogeneous in terms of their malpractice risk—that is, if $\theta_i = \theta$ for all *i*—then there will be no adverse selection and location choice will be driven entirely by relocation costs. If this is the case, then x_t will be negatively correlated with c_t but should be unrelated to any past relocation choices. This suggests an empirical test for adverse selection is a test of the predicted relationship $\frac{\partial}{\partial c_{t-1}} E[x_t \mid c_t, c_{t-1}] < 0$.

The model also predicts that past risk-taking behavior can affect future location decisions. If locating in a lower cost area imposes a higher wage penalty for physicians with an adverse malpractice history, then location choice and malpractice history are complementary signals.[13] If the signals are complements, physicians with prior malpractice claims have fewer incentives to choose low *c* because the wage penalty is harsher. Conversely, if the signals are substitutes, i.e., if location choice has less of an impact on wages for physicians with poor malpractice histories, then physicians with prior claims will choose lower *c*.

[12] Over time, the market beliefs about the physicians' types will converge to the true types, so as *n* gets large the marginal impact of location choice or a malpractice claim on the wage offer approaches zero.

[13] Formally, this is represented by $\frac{\partial^2 E_t[\hat{\theta}_{t+1}]}{\partial c_{t+1} \partial x_t} > 0$.

IV. Empirical Framework

The key empirical prediction from the analysis above is $\frac{\partial}{\partial c_{t-1}} E\left[x_t \mid c_t, c_{t-1}\right] < 0$, which can be tested using the following linear regression model:

$$x_{it} = \alpha c_{it} + \beta c_{it-1} + Z_{it}\gamma + \varepsilon_{it}$$

where Z is a vector of physician characteristics, including factors that could influence risk such as specialty, and ε is a random error term.[14] The ideal data set to test this model would be a panel of physicians that tracked their initial location decisions and any subsequent relocation, and also included information on their malpractice history and the expected malpractice costs of each area. Unfortunately, no such database is generally available, and what is available is considerably more limited.

This paper uses data from the National Practitioner Data Bank (NPDB), which has the advantages of being publicly available, covering malpractice events across the U.S., and tracking physicians over time. The NPDB is not a true panel, however, as a physician only appears in the data if the physician or the physician's representative (i.e., their insurer) makes a payment in a medical malpractice case. The nature of the data available influences the design of the empirical work for this study, so each data source is described in detail before discussing the empirical specifications used to test the predictions of the model.

[14] One might think that a more natural test of adverse selection would be to test for the choice of c as a function of θ or x. The reason the test is formulated in this matter is that any practical measure of θ or x in available data will be based on the number of claims. As discussed in the empirical identification section below, location choice could have a causal impact on the likelihood of a claim, suggesting that a test of location choice on measured risk would be inherently biased.

Measuring Physician Malpractice History

The NPDB is a nationwide database of payments in malpractice cases created by the Health Care Quality Improvement Act of 1986. The NPDB was created to collect information on malpractice claims in which the plaintiff receives some indemnity. In principle, all malpractice payments made in the United States, by or on behalf of a licensed health care provider, have been required to be reported to the National Practitioner Data Bank (NPDB) within 30 days since it became operational in late 1990. Information is provided on malpractice claims as well as on any adverse actions reported by state licensing boards. Hospitals are required to query the databank for the history of any physician applying for clinical privileges. Other professional organizations and groups are allowed to query the database, but they do not face the same requirements as hospitals (GAO, 2000).

For the purposes of this study, one of the most useful features of the NPDB is that it tracks physicians over time. Each time a payment is made for a physician, that physician is recorded under the same identifier. No information on physician gender or race is available, but information is provided on the age of physicians in 10 year categories from 20-29 to 80 and up. In addition, the state in which the physician was licensed at the time of the payment is recorded. Other data about the nature of the malpractice claim is included, such as whether the claim was resolved by settlement or by judgment at trial and the size of the payment made. There is also a description of the nature of the alleged error that was made. These error codes can be broken down into categories such as obstetrics, surgical, diagnostic, etc., which has sometimes been used to proxy for physician specialty (Kim, 2007).

The data used in this paper contain information on 129,990 physicians with at least one malpractice reported to the NPDB from September 1, 1990 through September 30, 2008. All payments reported on behalf of dentists, nurses, pharmacists, etc. are dropped. These include only payments by physicians who are licensed in all 50 states or the District of Columbia; payments from physicians in U.S. territories or overseas in the military are dropped. I also drop payments reported by state insurance funds, because these usually (though not exclusively) represent excess losses in addition to the amount paid by a physician's primary insurance carrier and including them might double count malpractice events. The vast majority of payments are reported by the primary insurance company, so this affects a small fraction of cases (and the results are robust if the state fund payments are included in the data).

Summary statistics from the physician level database are reported in Table 1. The table reports mean and standard deviations for all physicians, physicians with a single claim, and physicians with multiple claims. The top panel reports statistics for physicians of all ages. The first variable considered is physician age, which is broken into four categories: less than 40, 40 to 49, 50 to 59, and 60 or over. The age distribution is similar for physicians with single or multiple claims, and the largest age category is 40 to 49 in both groups. Diagnostic errors are the most common, but the distribution of errors is skewed towards surgery and obstetrics for physicians with multiple claims. This is consistent with the perception that surgical and obstetrics specialties are associated with high malpractice risk. Physicians average 1.5 payments in the NPDB. Just over 30% of physicians in the sample have multiple payments, and they average 2.8 payments per physician.

The NPDB has been the subject of criticism in the past, largely due to concerns that some malpractice claims go underreported (GAO, 2000). One of the major issues is that the data underreports malpractice payments due to the "corporate shield." This is a loophole that makes payments exempt from inclusion in the NPDB if the payment is made by or on behalf of a hospital or other corporation and the practitioner is dropped from the suit as part of a settlement agreement.

A related problem for this study is the NPDB's focus on payments as opposed to claims. The ideal database for this study would be one that tracked physicians over time and recorded all malpractice claims that they experienced. A relatively small fraction of all claims involve an indemnity payment (Kessler and McClellan, 2002), so a focus on payments, combined with the potential for underreporting, suggests that the data miss a significant fraction of malpractice risk. Because the estimation strategy does rely on having physicians with multiple claims, the underreporting to the NPDB reduces the likelihood that a physician is observed multiple times and reduces the power for this analysis. The NPDB rules are established at the federal level, however, so we have no reason to believe that these reporting issues vary by state. As long as these reporting issues are not systematically related to a state's malpractice environment, they should not systematically bias the risk profile of physicians.

Obviously, there are no direct measures of x and θ available in the NPDB. For the empirical analysis that follows, it is necessary to have some measure of an individual physician's risk level unavailable to the market at the time of the physicians' location decisions. We use the existence of future malpractice events as a proxy for a physician's malpractice risk. In other words, a physician is labeled high risk in time t if they are observed having a malpractice claim in time $t+n$. This measure takes advantage of the fact that while high risk physicians are more likely to have future events, the future events are unobserved (by hospitals and physicians) in the current period. Thus, the realization of future events should reflect current behavior without actually influencing it (which would cause empirical endogeneity problems).

Geographic Variation in Malpractice Costs

In order to study how expected malpractice risk affects the location and relocation of physicians, a key measurement issue is to have data on the geographic variation in expected malpractice costs. State is the lowest level of geography available in the NPDB, so the focus is necessarily on state-level variation in costs. The most natural predictor of state level costs to use is the malpractice reform climate in a state, i.e., the degree of tort reform. The medical malpractice liability system is subject to more legislative restrictions, particularly on damages, than virtually any other aspect of the civil justice system. These reforms were largely passed in response to rising malpractice insurance premiums, with the intent of lowering damages and reducing the cost of malpractice to physicians (Danzon, 2000). There is considerable variation across states, which has made it a useful tool for researchers looking for predictors of medical malpractice costs in other contexts, most notably Kessler and McClellan (1996; 2002a; 2002b).

This paper uses the 2nd edition of the Database of State Tort Law Reforms (Avraham 2006), a detailed compilation of all state tort reform efforts going back to 1980.[15] Even with information about which state had which reforms in place in which years, there is no obvious "right" way to implement the data in an empirical study. There are up to 10 reforms that are commonly thought to have an impact on medical malpractice: caps on pain and suffering, punitive or total damages, restrictions or caps on attorney contingency fees, collateral source rules, rules affecting joint and several liability, periodic payment of awards, state insurance funds that provide excess loss coverage, restrictions on evidence supporting punitive damages and the split recovery of punitive damages (whereby some damages are appropriated by the state).

[15] The data is available online at http://www.law.northwestern.edu/faculty/profiles/RonenAvraham/ (as of August 2009).

Kessler and McClellan (1996; 2002a; 2002b) and Kessler, Sage and Becker (2005) adopt a convenient specification that indexes the first 5 of these as "direct" reforms, with the remainder of reforms classified as "indirect." An alternative index is proposed in this paper, based on the number of reforms in place in a state. In this paper states are referred to as "low intensity," "medium intensity" or "high intensity" malpractice reform states if they have less than 4, 4 to 5, or more than 5 reforms in place, respectively.

Table 2 describes the prevalence of different reform types in states with direct and indirect reforms as well as states with low intensity, medium intensity and high intensity reform environments. The first two columns report the percent of states that have any direct or indirect reforms, respectively, that have each of the 10 different reform types mentioned above. So the table indicates 40.4% of states with any direct reform have a noneconomic damage cap in place, compared to 35.6% of states with any indirect reform. In fact, one of the more noticeable facts from the table is how closely the direct and indirect variables match. By 1991, when the NPDB became operational, a majority of states have at least one direct or indirect form (over 80% have any direct and over 90% have any indirect), so these variables largely indicate the pattern of the popularity of different reforms.

The final three columns of Table 2 indicate that the high intensity and medium intensity variables appear to be more indicative of variation in the strength of the reform environment. For instance, just 15.6% of states with a low intensity reform environment have a noneconomic damage cap, compared to 24.6% of the medium intensity reform states and 83.4% of the high intensity reform states. The high intensity reform is also correlated with a high propensity of other reforms that are considered important, such as collateral source rule reforms, joint and several liability and caps on punitive damages. More generally, the likelihood of every reform type is increasing between the low and medium intensity states, and for all but one is the likelihood increasing between the medium and high intensity states.

Other Data

To help ensure that the effect of the reforms is not simply picking up other aspects of the state legal or health care systems, it is important to include other important state characteristics in the analysis. State level data on the age distribution of the population is incorporated as dummy variables for four different age categories: 25 to 44, 45 to 54, 55 to 64 and 65 and up. The additional demographic controls included are the fraction of the state that is male, the fraction of the state that is white or African American (so Hispanics, Asians and other minorities are the omitted categories) and the annual per capita income in the state. These factors have all been shown to correlate with geographic variation in medical cost and treatment (c.f., Wennberg and Cooper, 1999; Wennberg, Fisher, and Skinner, 2002a; Wennberg, Fisher, and Skinner, 2002b).

Another important factor to control for is the strength of the local labor market for physicians. The number of physicians practicing in a state divided by the total state population is used as a proxy for this; if a state is a particularly attractive location or relocation option for physicians, this should be reflected with a higher rate of physicians per capita. The data on physicians and demographics all come from the Area Resource File (ARF), a compilation of numerous statistics from a variety of sources. The ARF reports data at the county level, but the data are aggregated to the state level for this analysis.

Empirical Specification

Let r_{it} denote the risk level of physician i who is practicing in area j in period t. The risk level is measured as an indicator variable that is equal to one if a physician is observed with a malpractice claim in some future period *t+n*, where $n > 0$, and zero otherwise. Consider the following empirical model:

$$r_{ijt} = \gamma \, reform_{jt} + Z_i \lambda + \psi_j \eta + \upsilon_{ijt}$$

The variable *reform* is some measure of the state malpractice liability reform environment, the vector *Z* is a vector of physician characteristics,[16] ψ is a vector of area-specific characteristics and υ is a random error term.

The model predicts that there should be a negative relationship between the expected malpractice cost in an area and the average risk of physicians practicing in that area, whether from moral hazard or adverse selection. Note that states with tort reform should be associated with a lower expected value of *c*. Thus, the expected sign of the coefficient on a tort reform variable is positive, i.e., $\gamma > 0$. A test of this model is analogous to a test of the static model, because the physicians' location choices are made before any prior malpractice history is observed. This model also cannot distinguish between moral hazard and adverse selection.

Because physicians are only observed in the NPDB if they experience subsequent malpractice events, we can only observe if physicians relocate if they have a second claim. Let $move_{it}$ be an indicator function for whether or not physician *i* relocated between periods *t* and *t+1*, where period *t+1* is the period in which the second malpractice event occurs. Let r_{it+1} be defined as before, except that it is an indicator for a future claim as of the time of the second claim, that is, it is equal to one only if a physician is observed with 3 or more claims in the

[16] One important characteristic for identification of the empirical work model is the time in which the first claim occurs. Because our data are censored, physicians whose first claim occurs later in the period covered by our sample have a mechanically lower probability of having a second claim in the NPDB. Thus, the inclusion of year effects for time of first claim is an important covariate to control for the individual variation in censoring. Note that all results are robust to alternative specifications of the model that fix a constant period of time between malpractice claims.

NPDB. The test for adverse selection used in this paper is defined by the following empirical model:

$$r_{ijt+1} = \xi\, move_{it} + \gamma_1\, in\_reform\_both_i + \gamma_2\, move\_to\_reform_i + \gamma_3\, move\_from\_reform_i + Z_i\lambda + \psi_j\eta + \upsilon_{ijt}$$

The vectors *Z* and ψ are defined as before. The variables *reform_both*, *move_to_reform* and *move_from_reform* refer to the following three distinct location and relocation patterns:

- *in_reform_both*: a physician that initially located in a reform state and stayed there
- *move_to_reform*: a physician that initially located in a non-reform state and relocated to a reform state
- *move_from_reform*: a physician that initially located in a reform state and relocated to a non-reform state

These comparisons are all relative to a physician who located in a non-reform state and remained there.

The expected signs of the coefficients on the malpractice variables depend on whether moral hazard or adverse selection is the dominant behavioral effect. If there is only moral hazard and not adverse selection, then being in a reform state should have an identical impact on behavior regardless of when a given physician located there. Formally, this suggests that $\gamma_1 > 0$, $\gamma_2 > 0$, $\gamma_1 = \gamma_2$, and $\gamma_3 = 0$. If adverse selection is present, the model suggests that past location will be predictive of risk even conditional on current location, implying $\gamma_3 \neq 0$ and $\gamma_1 \neq \gamma_2$.

Beyond this, the predictions of the model about the expected relationships between γ_1, γ_2 and γ_3 with adverse selection are somewhat ambiguous. We can make the general conclusion that physicians moving *away* from the low cost area should be less risky than physicians moving *to* the low cost area, implying $\gamma_2 > \gamma_3$. The predicted signs of γ_2 and γ_3, however, are ambiguous. If high productivity physicians have sufficiently strong incentives relative to low productivity physicians to relocate to the high cost area after a malpractice claim, then we expect $\gamma_3 < 0$. Similarly, if the low productivity physicians are more likely to relocate to the low cost areas even after they experience a claim, then we expect $\gamma_2 > 0$.

Identification

The key to the validity of the empirical tests is that the tort reform environment and the likelihood of a future claim act as true proxies for expected malpractice cost and the current risk of physicians respectively. There are three principle challenges to identification:

- The possibility that state adoption of tort reform is correlated with other state characteristics that drive the location decisions of physicians
- The possibility that malpractice reforms could have an impact on the number of malpractice events independently of a physician's individual risk
- The possibility that relocation could have a causal effect on the probability of a future malpractice event

The first issue is a straightforward statement about omitted variable bias: since our measures of malpractice environment are all at the state level it is important to capture the other relevant features of a state that could drive physician relocation decisions or malpractice risk. The inclusion of detailed state characteristics and state fixed effects help defend against this possibility.

One potentially important state characteristic that is not captured in the primary models is the presence of managed care organizations (MCOs). Danzon (2000) argues that tort reform was more likely to be adopted in states where MCOs had a strong presence. While it is not obvious that MCOs on their own should cause a bias, they are correlated with numerous other aspects of the health care system that could be related to both risk and the location decisions of physicians, thus compromising the results. MCO penetration is not included in the primary model because we only have consistent data through 2003. However, the appendix shows that the main findings are fully robust when MCO penetration is included and the analysis is restricted to these years.

The second challenge to identification is the possibility that tort reform measures could have affected the number of malpractice events a physician experiences in ways that are independent of a physician's individual behavior. Proponents of the adoption of tort reform often claim that it provides a means to deter "junk lawsuits." If this were the case, then we would expect to see a negative relationship between the presence of some kind of tort reform in a state and the number of malpractice events experienced in that state. Note, however, that this would make physicians in tort reform states look less risky than they really are: the opposite of the predicted effect. This suggests that the estimates using the tort reform measures may be conservative.[17]

Finally, the third possibility is that relocation itself causally affects the probability of a future malpractice event. Suppose that being the target of a successful suit made a physician a more attractive target for local plaintiffs, either because potential claimants became more willing to file, or attorneys became more willing to accept cases against the physician. In this case, relocating to a new area might lower the likelihood of a future suit. It is important to note, however, that this effect would be true regardless of *where* a physician relocated. The empirical specification can identify the direct effect of relocation independently of the effect of relocating between states with different malpractice environments, because some physicians who relocate may do so from one tort reform state to another (or from one non-reform state to another). Thus, the estimates of location choice can be thought of as coming from a difference-in-differences model, where the identifying variation comes from differencing the outcomes of individuals who

[17] In the Appendix, empirical tests suggest that the malpractice reform measures have a consistently negative but statistically insignificant association with the number of claims per physician. This confirms that any causal impact of tort reform on the likelihood of a claim weakly biases this paper away from finding an effect.

relocate *between* malpractice environments from those who relocate *within* malpractice environments.[18]

Note that these last two issues arise because of the censored nature of the data. The NPDB only includes physicians at a point in time in the event that they experience a paid malpractice claim. The problems discussed here involve a situation in which the likelihood of such a claim is correlated with the variables in our analysis. That is not to say, however, that the model is identified only under the assumption of random censoring. In fact, the theoretical model predicts a specific form of nonrandom censoring that is tested here. Rather, identification requires that the censoring be driven solely by variation in the risk-taking behavior of physicians, for which our tort reform and relocation variables act as proxies.

V. Estimation Results

In Table 3, we summarize the relationship between the observed risk of physicians and the likelihood of relocation in the high and low intensity reform states. Specifically, we summarize the likelihood that a physician is observed with at least 2 or 3 events in the NPDB as well as the fraction of physicians that relocate between the first and second events by reform intensity. Note that to allow for sufficient time to observe physicians in later periods, the table only reports the averages for physicians whose first claim occurred by 2001.

For these physicians, 36.0% have a second event in the NPDB, and of those 44.6% have a third event. Physicians in the low intensity reform states are less likely (34.1%) to have a second claim than physicians high intensity reform states (36.6%). Similarly, physicians in the low intensity reform states are also less likely to have a third claim. Finally, we see that about 6.2%

[18] This also illustrates why we do not adopt an alternative estimation specification that directly estimates location choice as a function of observed risk.

of physicians relocate between the first and second events. Relocation is more likely for physicians initially choosing the low intensity reform states (7.7%) than for those initially in the high intensity reform states (4.9%). Similar patterns are observed for physicians under 40 at the time of the first event and for physicians whose first NPDB event involves an (alleged) error associated with a high risk specialty (obstetrics or surgery). Overall, these raw numbers suggest that physicians locating in states with a favorable malpractice environment exhibit higher risk.

Table 4 presents the estimation results for the base model, correlating the observed risk of physicians to the initial choice of malpractice environment. The dependent variable for all regressions models is the likelihood that a physician experiences a second malpractice event. Each column represents a different regression using a different specification for the malpractice reform environment, and the regressions are run separately on all physicians, physicians under 40 at the time of the first claim and physicians whose first claim indicates a high risk specialty.

The regression results strongly support the finding in the raw data that physicians in states with a more favorable malpractice environment exhibit higher risk. The coefficients on the reform variables are positive for all specifications but one, and many are statistically significant at the 10% level or better. For example, the results suggest that physicians in high intensity reform states are 4.1 percentage points more likely to experience a second malpractice claim, an increase of approximately 11% (using the baseline risk in Table 3). The correlations appear stronger for the younger physicians and weaker for physicians in the high risk specialties. If the findings are, indeed, at least partly attributable to adverse selection, then the former result could be due to the greater mobility of younger physicians—they are more likely to relocate, as seen in Table 3, increasing the potential for adverse selection among younger physicians. The latter result could be due to the fact that malpractice claims are more common among the high risk specialties, making the incidence of future claims a poorer signal of risk (both conceptually and econometrically).

Table 5 reports the estimation results for the model correlating the observed risk of physicians to the initial location choice and subsequent relocation. The overall setup of the table is similar, with each column representing regression results using a different specification of the reform environment. In this model, however, there are three separate variables for location: being in a reform state for both events, moving to a reform state from a non-reform state between the first and second events, and moving to a non-reform state from a reform state between the first and second events. The omitted comparison group is comprised of physicians located in a non-reform state in both periods.

There are several findings to note from the table. The first is that locating in a reform state is still associated with an elevated level of observed risk for physicians. The coefficient on initially locating in a reform state and remaining there is positive and statistically significant for all measures except the presence of punitive damage caps.[19] The table also indicates that physicians who are initially located in a favorable malpractice environment but relocate to a less favorable environment are lower risk. This finding is less robust statistically, but the coefficient is consistently negative and significant for the noneconomic damage cap and the high intensity reform indicator in the full sample. Finally, the table indicates that only the initial location in a favorable environment is associated with elevated risk. Physicians who relocate to a favorable environment after a claim appear to be equally as risky as physicians who stay in an unfavorable environment.

[19] The lack of an effect of punitive damage caps is not surprising because punitive damages are rare in medical malpractice cases (Eisenberg et al., 1997). So, the punitive caps likely have less of an impact on expected risk.

These findings suggest that the correlation between malpractice environment and physician risk observed in Table 3 and Table 4 is driven by adverse selection and not moral hazard. Recall that a pure moral hazard model predicts that only the current location matters, which would require that the coefficients on being in a reform state in both periods and the coefficient on moving to the reform state both be positive and equal. The fact that only the initial location choice is correlated with elevated risk suggests that the correlation is not driven by the fact that simply being in the favorable malpractice environment makes physicians act riskier. Rather, it suggests that the physicians who initially locate in the favorable environments have systematically different and riskier behavior.

The findings also suggest that relocation *from* a reform state is a stronger predictor of risk than relocation *to* a reform state. One possible interpretation of these findings is that the high risk physicians tend to relocate to the low cost area early on in their career, before their malpractice history is realized. The high productivity-low risk physicians only choose to relocate away from a favorable malpractice environment once they have experienced a claim, because they have enhanced incentives to offer the market a favorable signal of type.[20]

As was the case in Table 4, the findings are generally consistent when we limit the sample to younger physicians or physicians in high risk specialties. Being in the reform state in both periods is consistently associated with higher observed levels of risk. Moreover, also as before, the effect is stronger for young physicians and weaker for physicians in high risk specialties. While relocation away from the reform states is insignificant in most specifications, it consistently has a negative coefficient.

[20] This latter result, with low risk physicians relocating to the high cost areas after a claim, seems broadly consistent with the case of malpractice risk and location choice being complementary signals.

VI. Conclusion

The impact of the high cost of malpractice liability on the behavior of physicians is a hotly contested issue among policymakers. This paper suggests that there is a positive correlation between the intensity of malpractice liability reform in a state and number of malpractice payments made by physicians. These results suggest that an unintended consequence of tort reform might be to increase patient exposure to negligent and harmful care, as has often been suggested by the opponents of tort reform. Where this paper differs, however, is in the mechanism through which this elevated risk manifests itself. We find little evidence that tort reform makes a given physician act in a riskier fashion; rather, we find that a favorable malpractice reform environment in a given state appears to attract riskier physicians to practice medicine there.

The implication of these findings for the overall efficacy of tort reforms is unclear. The empirical results of this paper do not provide any means to quantify the potential welfare effects (say, by estimating the adverse health consequences associated with high risk physicians). What the findings do suggest, however, is that the welfare implications of reform potentially differ if they are enacted on a local basis as opposed to a national basis. The results of this paper suggest that adverse selection is the dominant behavioral effect of malpractice liability. This implies that enacting local reform could lower malpractice costs but could also increase the exposure of patients in that area to risk. A national reform, however, would lower costs in all areas while leaving the aggregate level of risk potentially unchanged.[21] Of course, the presence of geographic variation in expected malpractice costs does provide the market some opportunity to

[21] This assumes a very strict interpretation of our results in which there is *no* potential for moral hazard. If there is some moral hazard, e.g. among the low risk physicians who do not appear in the NPDB a sufficient number of times for our analysis, then their could be some impact of a national reform on aggregate risk.

attain greater separation between the high productivity and low productivity physicians in equilibrium (that is, their wages are closer to their true marginal productivity), suggesting that the adverse selection might actually be welfare enhancing relative to reform that equalized malpractice costs across all areas.

One type of reform that these results do appear to support is the mandatory public disclosure of malpractice history. State laws mandating disclosure of past malpractice claims have grown in popularity in recent years, though the evidence suggests that in their current form they only affect a very small number of physicians (Helland and Lee, 2008). An important limitation of these laws is that they only provide information about malpractice claims in which the state at which the physician is licensed. The results of this paper suggest that granting public access to a national database, like the NPDB, would provide a stronger signal of a physician's possible risk level to prospective patients in tort reform states.

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Table 1. Summary statistics of physician data from the NPDB

	All Physicians		Physicians: 1 Event		Physicians: 2+ Events	
	Mean	SD	Mean	SD	Mean	SD
Physician age (%):						
Age ≤39	28.5	45.2	28.2	45.0	29.2	45.5
Age 40 to 49	35.0	47.7	33.8	47.3	37.5	48.4
Age 50 to 59	22.7	41.9	22.5	41.8	23.1	42.1
Age ≥ 60	12.6	33.2	14.1	34.8	9.2	28.9
Error Code (%):						
Diagnostic	37.1	48.3	39.4	48.9	31.8	46.6
Anesthesia	4.0	19.6	4.7	21.2	2.4	15.3
Surgical	22.7	41.9	19.0	39.2	31.1	46.3
Medication	6.4	24.4	7.0	25.5	5.0	21.7
Obstetrics	7.3	25.9	6.0	23.8	10.0	30.0
Treatment	18.9	39.2	19.8	39.9	16.9	37.5
Monitoring	1.5	12.0	1.6	12.7	1.0	10.2
Other	2.2	14.7	2.4	15.2	1.8	13.4
Number of Events	1.6	1.8	1.0	0.0	2.9	2.8
Physicians with Multiple Events (%)	30.8	46.2				
Observations	129,990		89,928		40,062	

Note: For physicians with multiple events, all statistics are from the first events.

Table 2. Composition of reform types using different indexes of the intensity of malpractice liability reform

	Has any Direct (%)	Has any Indirect (%)	Low Intensity (%)	Medium Intensity (%)	High Intensity (%)
Direct Reforms					
Noneconomic Damage Cap	40.4	35.6	15.6	24.6	83.4
Punitive Damage Cap	51.3	43.2	25.9	38.5	81.7
Cap on Total Damages	14.9	11.1	5.3	17.5	15.4
Collateral Source Rule	72.7	64.0	21.6	79.9	92.6
Indirect Reforms					
Joint and Several Liability	75.7	74.6	47.2	82.5	90.3
Contingency Fee Cap	31.9	30.8	15.0	32.0	49.1
Mandatory Periodic Payments	67.4	62.0	18.9	77.2	93.1
State Liability Fund	18.0	20.7	14.3	17.8	33.1
Pun. Damages: Evidence Rules	67.0	65.2	44.9	65.7	85.1
Pun. Damages: Split Recovery	12.7	11.2	0.0	7.1	36.0
N	684	776	301	338	175

Note: Table reports the percent of states with different reforms by different measures of the overall intensity of reform in a given year. Data are based on 814 state-year combinations, including the District of Columbia. Low intensity states are those with 0-3 reforms, medium intensity are those with 4 or 5 reforms, and high intensity states are those with 6 or more total reforms.

Table 3. Summary of the number of NPDB events and relocation by the initial practice location choice

	Physicians in All States	Physicians in States with: Low Intensity Reform	High Intensity Reform	Difference (High-Low)
		All Physicians		
Has Second Event	0.360	0.341	0.366	0.025
Has Third Event	0.446	0.416	0.434	0.018
Relocates Between First and Second	0.062	0.077	0.049	-0.028
		Physicians Under 40		
Has Second Event	0.365	0.334	0.378	0.044
Has Third Event	0.450	0.419	0.433	0.014
Relocates Between First and Second	0.094	0.117	0.073	-0.044
		Physicians with Errors High Risk Specialties		
Has Second Event	0.480	0.459	0.486	0.027
Has Third Event	0.530	0.500	0.520	0.020
Relocates Between First and Second	0.059	0.068	0.050	-0.018

Note: The likelihood of having a third event or relocating between the first and second event is conditional on having at least two events.

Table 4. Estimated relationship between the initial malpractice environment and the likelihood of a future malpractice event

	Pain and Suffering Damage Cap	Punitive Damage Cap	Joint and Several Reform	Contingency Fee Regulation	Any Direct Reform?	Medium Intensity Reform	High Intensity Reform
				All Physicians			
In Reform State	0.021 (0.015)	0.002 (0.013)	0.059 (0.013)**	0.031 (0.018)*	0.034 (0.016)**	0.010 (0.013)	0.041 (0.018)**
				Physicians Under 40			
In Reform State	0.018 (0.019)	0.010 (0.015)	0.082 (0.014)**	0.042 (0.021)**	0.051 (0.018)**	0.027 (0.016)	0.048 (0.023)**
				Physicians with Errors in High Risk Specialties			
In Reform State	0.021 (0.017)	-0.006 (0.014)	0.059 (0.016)**	0.033 (0.020)	0.028 (0.019)	0.008 (0.015)	0.038 (0.019)*

Notes: The table reports the estimated coefficients from a linear probability model of the probability of a second claim in the NPDB as a function of whether or not the physician is located in a low cost malpractice state at the time of the first claim. Each column reports the results from a separate regression using a different reform variable or set of variables on either the full sample of physicians, physicians under 40 or physicians in high risk specialties. All regressions include fixed effects for the year of payment, category of alleged error and dummy indicators for physician age, as well as state level controls for income, race, age distribution and number of physicians per member of the population. Robust standard errors adjusted for clustering at the state level are reported in parentheses. A * or ** represents statistical significance at the 1% or 5% level respectively.

Table 5. Estimated relationship between initial malpractice environment, relocation to and from high cost malpractice environments and the likelihood of a future event

	Pain and Suffering Damage Cap	Punitive Damage Cap	Joint and Several Reform	Contingency Fee Regulation	Any Direct Reform?	Medium Intensity Reform	High Intensity Reform
				All Physicians			
In Reform State Both Periods	0.024 (0.012)**	-0.003 (0.014)	0.044 (0.011)**	0.046 (0.013)**	0.048 (0.012)**	0.032 (0.012)**	0.050 (0.013)**
Moved to Reform State	0.011 (0.013)	-0.022 (0.015)	-0.011 (0.013)	0.011 (0.028)	0.017 (0.013)	-0.001 (0.012)	-0.002 (0.011)
Moved from Reform State	-0.048 (0.019)**	-0.027 (0.023)	-0.018 (0.024)	-0.022 (0.023)	-0.004 (0.021)	-0.012 (0.013)	-0.063 (0.029)**
				Physicians Under 40			
In Reform State Both Periods	0.027 (0.016)*	-0.007 (0.021)	0.046 (0.018)**	0.045 (0.019)**	0.054 (0.023)**	0.032 (0.019)*	0.058 (0.020)**
Moved to Reform State	0.015 (0.019)	-0.008 (0.033)	0.006 (0.024)	0.008 (0.033)	0.035 (0.036)	0.007 (0.027)	0.024 (0.016)
Moved from Reform State	-0.048 (0.032)	-0.059 (0.036)	-0.015 (0.034)	-0.045 (0.031)	-0.020 (0.035)	0.008 (0.026)	-0.116 (0.039)**
				Physicians with Errors in High Risk Specialties			
In Reform State Both Periods	0.028 (0.012)**	0.004 (0.013)	0.023 (0.013)*	0.035 (0.015)**	0.048 (0.016)**	0.017 (0.014)	0.049 (0.015)**
Moved to Reform State	0.029 (0.021)	0.014 (0.022)	-0.040 (0.019)**	0.006 (0.033)	0.055 (0.026)**	-0.024 (0.021)	-0.014 (0.030)
Moved from Reform State	-0.031 (0.031)	-0.005 (0.033)	-0.032 (0.039)	-0.002 (0.042)	0.017 (0.037)	0.028 (0.021)	-0.054 (0.047)

Notes: The table reports the estimated coefficients from a linear probability model of the likelihood of a third malpractice claim against the location and relocation decisions of physicians before the first and second claims. Each column reports the results from a separate regression using a different reform variable or set of variables on either the full sample of physicians, physicians under 40 or physicians in high risk specialties. All regressions include fixed effects for the year of payment, category of alleged error and dummy indicators for physician age, as well as state level controls for income, race, age distribution and number of physicians per member of the population. Robust standard errors adjusted for clustering at the state level are reported in parentheses. A * or ** represents statistical significance at the 1% or 5% level respectively.

Appendix

This appendix provides additional analysis to support validity of the main findings in the text. First, we explore the relationship between the presence of tort reform and the number of malpractice events in the NPDB per physician. To estimate this relationship, we aggregate the number of malpractice payments in the NPDB to the state-year level, and then calculate the rate of paid claims per 100 physicians. This rate is then regressed against the tort reform variables used in the text.

Appendix Table 1 reports the estimated relationship between reforms and the number of claims. The table reports estimates using region and state fixed effects, and all standard errors are calculated allowing for clustering at the state level. The table indicates that the presence of malpractice liability reforms is largely uncorrelated with the number of claims in the NPDB. In all cases with state fixed effects, the coefficient estimates suggest tort reform is consistent with a reduction of 0.01 to 0.1 claims per 100 physicians, though none of the effects are statistically significant. In the model without state fixed effects, the models are inconsistent in sign, and most are statistically insignificant.

The coefficient on the joint and several liability reform variable is positive and significant without state fixed effects, which runs contrary to our assertion that the impact of the reforms should be negative (thus making our effects conservative). We note, however, that our primary measure of reform—the intensity of reform—is negatively correlated with the number of reforms. Given that the findings in the paper for the intensity of reform are highly consistent with the findings for joint and several liability reform (in that both variables consistently have the same signs and similar significance), we feel that any impact of the reforms on the number of claims reported to the NPDB is unlikely to be driving the key results of the paper.

It is probably worth considering why the effects are so small, given that Kessler and McClellan (2002b) find some evidence that tort reforms are associated with fewer claims. One possible explanation is that tort reform is more effective at reducing the number of "weak" lawsuits, those with a low *ex ante* probability of success. This could reduce the number of unpaid claims, which still can have nontrivial defense costs, without substantially reducing the total number of claims.

Another potential limitation of the empirical work is the lack of controls for the presence of managed care, which could be correlated with the presence of tort reform. The second test considered in this appendix validates the robustness of the results when we include controls for MCO penetration. Appendix Table 2 reports the estimated effects of location choice on the probability of a future event. These estimates are essentially the same as reported in Table 4 and Table 5, except that state-year MCO penetration at the time of the first event is included as an independent variable. The table shows that the results when MCO penetration is included are highly consistent with the main findings. The likelihood of a second claim is strongly, positively correlated with the presence of reform in a state. Moreover, the positive correlation appears to be driven by initial location decision, and we see no effect of physicians relocating to an area. This suggests that the findings in the paper are not driven by the possibility that the tort reform measures are correlated with MCO penetration.

Finally, in Appendix Table 3 we verify that the likelihood of physician relocation is correlated with the tort reform environment. This correlation indicates that tort reform is viewed as lowering expected malpractice costs, making an area more attractive to physicians. The table is set up identically to Table 4; the only change is that relocation is used as the dependent variable.

The results of the table suggest that physicians are less likely to relocate out of tort reform states. Among the reforms considered individually, we see very little effect overall. Both the direct reform index and the reform intensity index are, however, strongly correlated with a lower likelihood of relocation between the first and second malpractice claims. This is consistent with the previous evidence suggesting that the presence of malpractice liability reform attracts physicians to practice medicine in an area.

Appendix Table 1. Correlation between malpractice reforms and the aggregate frequency of NPDB events

	Pain and Suffering Damage Cap	Punitive Damage Cap	Joint and Several Reform	Contingency Fee Regulation	Any Direct Reform?	Medium Intensity Reform	High Intensity Reform
				Region Fixed Effects			
Impact of Reforms	0.049	0.025	0.296	0.043	-0.004	-0.090	-0.039
	(0.104)	(0.089)	(0.010)**	(0.113)	(0.111)	(0.076)	(0.060)
				State Fixed Effects			
Impact of Reforms	-0.001	-0.006	-0.042	-0.378	-0.008	-0.033	-0.090
	(0.065)	(0.073)	(0.053)	(1.414)	(0.058)	(0.116)	(0.097)

Notes: Table reports the estimated coefficients from regression of the total number of malpractice payments reported to the NPDB per 100 physicians in a state in a year against different measures of the malpractice environment. Regressions are at the state year level. All regressions include controls for income, race, age distribution and number of physicians per member of the population and fixed effects for year. Standard errors adjusted for clustering by state are reported in the parentheses. A * or ** represents statistical significance at the 1% or 5% level respectively.

Appendix Table 2. Estimated relationship between initial malpractice environment, relocation and the probability of a future malpractice event controlling for MCO penetration

	Pain and Suffering Damage Cap	Punitive Damage Cap	Joint and Several Reform	Contingency Fee Regulation	Any Direct Reform?	Medium Intensity Reform	High Intensity Reform
				Likelihood of a Future Claim			
In Reform State	0.025	0.008	0.062	0.032	0.034	0.008	0.047
	(0.019)	(0.016)	(0.013)**	(0.019)*	(0.017)**	(0.015)	(0.021)**
				Relocation and Future Claims			
In Reform State Both Periods	0.016	0.001	0.046	0.043	0.046	0.032	0.048
	(0.013)	(0.014)	(0.011)**	(0.013)**	(0.011)**	(0.013)**	(0.014)**
Moved to Reform State	0.015	-0.016	-0.010	0.018	0.018	0.004	-0.002
	(0.014)	(0.014)	(0.012)	(0.029)	(0.012)	(0.013)	(0.012)
Moved from Reform State	-0.042	-0.026	-0.016	-0.024	0.000	-0.009	-0.066
	(0.019)**	(0.025)	(0.024)	(0.023)	(0.021)	(0.013)	(0.030)**

Notes: The table reports the estimated coefficients from a linear probability model of the likelihood of a third malpractice claim against the location and relocation decisions of physicians before the first and second claims. Each column reports the results from a separate regression using a different reform variable or set of variables on either the full sample of physicians, physicians under 40 or physicians in high risk specialties. All regressions include fixed effects for the year of payment, category of alleged error and dummy indicators for physician age, as well as state level controls for income, race, age distribution and number of physicians per member of the population. Robust standard errors adjusted for clustering at the state level are reported in parentheses. A * or ** represents statistical significance at the 1% or 5% level respectively.

Appendix Table 3. Estimated relationship between malpractice environment at the time of the first event and the likelihood of relocation

	Pain and Suffering Damage Cap	Punitive Damage Cap	Joint and Several Reform	Contingency Fee Regulation	Any Direct Reform?	Medium Intensity Reform	High Intensity Reform
				All Physicians			
In Reform State	-0.005	0.001	-0.017	-0.012	-0.024	-0.014	-0.019
	(0.007)	(0.006)	(0.007)**	(0.010)	(0.010)**	(0.008)	(0.009)**
				Physicians Under 40			
In Reform State	0.005	-0.011	-0.042	-0.019	-0.044	-0.029	-0.036
	(0.011)	(0.014)	(0.014)**	(0.022)	(0.018)**	(0.015)*	(0.016)**
				Physicians with Errors in High Risk Specialties			
In Reform State	0.004	-0.0002	-0.012	-0.005	-0.016	-0.012	-0.005
	(0.006)	(0.006)	(0.006)*	(0.008)	(0.009)*	(0.007)	(0.008)

Notes: The table reports the estimated coefficients from a linear probability model of the probability that a physician's second payment in the NPDB is in a different state than the first, i.e., relocation, as a function of whether or not the physician is located in a low cost malpractice state at the time of the first claim. Each column reports the results from a separate regression using a different reform variable or set of variables on either the full sample of physicians, physicians under 40 or physicians in high risk specialties. All regressions include fixed effects for the year of payment, category of alleged error and dummy indicators for physician age, as well as state level controls for income, race, age distribution and number of physicians per member of the population. Robust standard errors adjusted for clustering at the state level are reported in parentheses. A * or ** represents statistical significance at the 1% or 5% level respectively.