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UNINTENDED CONSEQUENCES OF PRODUCTS LIABILITY:  
EVIDENCE FROM THE PHARMACEUTICAL MARKET

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**ABSTRACT**

In a complex economy, production is vertical and crosses jurisdictional lines. Goods are often produced by an upstream national or global firm and improved or distributed by local firms downstream. In this context, heightened products liability may have unintended consequences on product sales and consumer safety. Conventional wisdom holds that an increase in tort liability on the upstream firm will cause that firm to (weakly) increase investment in safety or disclosure. However, this may fail in the real-world, where upstream firms operate in many jurisdictions, so that the actions of a single jurisdiction may not be significant enough to influence upstream firm behavior. Even worse, if liability is shared between upstream and downstream firms, higher upstream liability may mechanically decrease liability of the downstream distributor and encourage more reckless behavior by the downstream firm. In this manner, higher upstream liability may perversely increase the sales of a risky good. We demonstrate this phenomenon in the context of the pharmaceutical market. We show that higher products liability on upstream pharmaceutical manufacturers reduces the liability faced by downstream doctors, who respond by prescribing more drugs than before.

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A common feature of modern, complex economies is vertical production that crosses jurisdictional lines. Technological development and specialization is associated with vertical chains of production, where upstream firms supply inputs for downstream firms who add value and sell to consumers. Moreover, firms at all levels have grown in scale and scope, and they now often serve many markets across a range of different jurisdictions. This geographic expansion is perhaps even more pronounced for upstream firms, because downstream firms, such as distributors and retailers, tend to be local or at least retain a well-defined local presence.

To remain relevant and effective, tort rules and other legal structures need to account for the interactions among firms in a vertical chain of production. To some extent, tort law has successfully incorporated the reality of vertical production. In the 1800s, a doctrine called “privity” prevented individuals from suing upstream firms for injuries from products of downstream firms. Cases such as *MacPherson v. Buick Motor Company* (N.Y. 1916) and *Smith v. Peerless Glass Co* (N.Y. 1932) abandoned the doctrine of privity and allowed consumers to sue firms further upstream (Prosser, 1960). Indeed, contemporary products litigation is now characterized by suits against several firms in the vertical chain of production and has become quantitatively significant.<sup>1</sup> Overall torts liability grew four times faster than the overall economic growth rate between 1930 and 1994 (Sturgis, 1995). By 2009, total payments in products liability suits alone amounted to \$248.1 billion, or 1.74% of U.S. GDP (Towers Watson, 2010). In health care, suits against doctors amount to 1-2% of physician expenditures (Mello, Chandra, Gawande, & Studdert, 2010), and suits against drug companies amount to 2.26% of all drug expenditures.<sup>2</sup>

However, an important way in which tort law has lagged the modern economy is in the persistence of local, rather than national or global tort rules. States set tort rules, even though firms may produce for national and even global markets. This has encouraged beggar-thy-neighbor policies by states who may have incentives to shift liability from local downstream defendants to upstream national defendants lacking a local presence (Krauss, 2002). For instance, 22 states have reduced the products liability local retailers face but not the liability that upstream manufacturers face (Shepherd, 2012). Nearly 30 states have caps on total or non-economic damages that physicians face in medical

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<sup>1</sup> For example, plaintiffs sue both the manufacturer of the car whose tire burst and the manufacturer of the tire (e.g., *In re Bridgestone/Firestone, Inc.*, S.D. Ind. 2003), the home builder that used contaminated materials and the maker of those materials (e.g., *In re Chinese Manufactured Drywall Products*, E.D. La. 2010), the grocer that used spoiled food and the company that supplied the grocer with the spoiled food (e.g., cases against retailers and farmers implicated in the 2006 E. coli outbreak), and the doctor that prescribed a drug as well as the company that produced it (e.g., *Wyeth v. Levine*, U.S. 2009) This last example is also the topic of the empirical application in this paper.

<sup>2</sup> This estimate is derived from all settlement special items reported in the income statement. For pharmaceutical companies this represents provisions to alter reserves for litigation and settlement. For other companies the amount would include insurance payments from the firms general liability policy but pharmaceutical firms do not typically have insurance against losses in litigation. As such the sum of the settlement special items represents unexpected payments in litigation. Although some of this litigation is likely not related to product liability the vast majority of losses in excess of reserves is likely major product liability cases—a fact reflected by disclosures in the 10k statements. We sum the total special reserves incurred from 2002-2008 and divide this by total sales over the same period to get the ratio of 2.26%.

malpractice actions. In litigation involving injuries from prescription drugs or devices, these caps shift liability from local doctors to upstream national medical products and drug companies. In general, while the legal system recognizes the multiple-jurisdiction problem, the strategies employed for addressing it are widely viewed as inadequate.<sup>3</sup>

So far, the economics literature on tort liability and products regulation has neglected the relationship between tort rules and vertical production.<sup>4</sup> The majority of the literature on products liability assumes a single producer rather than a chain of production (William M. Landes & Posner, 1985; Polinsky & Rogerson, 1983; Spence, 1977). The economics literature on joint and several liability does tackle the problem of multiple tortfeasors (e.g., Landes and Posner 1980, Sykes 1983, Kornhauser and Revesz 1989, Miceli and Segerson 1991, Currie and MacLeod 2008). However, this literature typically abstracts from the contracting between upstream and downstream firms that is central to vertical production.<sup>5</sup>

A partial exception is Hay and Spier (2005). That paper discusses optimal allocation of tort liability between a producer and a consumer when the consumer's use of a product may injure third parties. In principle, one can apply the model to upstream and downstream firms, instead of producers and consumers. However, Hay and Spier, like the articles cited in the prior paragraph, assume that all actors operate in one jurisdiction. Moreover, their model assumes the consumer (or, by analogy, the downstream firm) can contract on quality. This strong assumption contrasts with the large literature on incomplete contracts (Bolton & Dewatripont, 2005).

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<sup>3</sup> One such strategy is the use of model codes and restatements of law that are meant to harmonize laws across states. However, these uniformity movements tend stop at the national border, and they often have patchy adoption across states. For example, about half the states have punitive damages caps and less than two-third have reformed joint and several liability (Malani & Reif, 2013). Federal diversity jurisdiction allows federal courts to hear tort cases involving parties from different states. Not all products liability cases can be moved to federal court under this jurisdictional rule because many national upstream firms have enough of a presence in each state that they can be considered a local party. Even when cases are moved to federal court, the federal court must apply local state law (*Erie Railroad Co. v. Tompkins*, U.S., 1938). The second device is the class action suit. Yet the hurdles to meet class action status remain high. The threshold for certification is even higher if the class involves residents from multiple states. (See for example Pace et al. (2007) who find that 82% of the class actions in their sample involved residents of a single state.) Moreover, these suits have been criticized as resulting in settlements that benefit producers and plaintiffs' attorneys at the expense of plaintiffs (Hensler, 2000). The last is national regulation of safety. These regulations are porous and leave a large role for state tort actions (e.g., *Wyeth v. Levine*, U.S., 2009). Further, the legal system tends to disfavor preemption of state suits by federal regulation, so product liability still varies across states (Schwartz & Silverman, 2009).

<sup>4</sup> This modeling choice contrasts, for example, with the economic literatures on tax and regulatory competition, which takes as a central assumption that legal rules vary across jurisdictions and that firms can operate in multiple jurisdictions and can change jurisdictions to avoid regulation (e.g., Oates and Schwab 1988). The regulatory competition literature does not address the exact analogue of the case we consider here: the effect of a single jurisdiction's liability rules when firms operate in that and other jurisdictions.

<sup>5</sup> This contracting has an important effect on welfare: it may be possible by allocating liability asymmetrically among tortfeasors to achieve the first best. This is similar the insight that contracting between agents can address moral hazard in teams without a budget breaker (Legros and Matthews 1993).

In this paper we present and empirically test a model of products liability that studies the implications of both vertical and multi-jurisdictional production. The upstream firm in our model operates in multiple jurisdictions, in contrast to Hay and Spier.<sup>6</sup> Tort rules allocate liability between upstream and downstream firms. Total damages are constrained to be equal to consumers' injuries, so higher upstream liability implies lower downstream liability and vice-versa. We assume that consumers cannot contract over product safety, so that products liability can theoretically improve welfare. We also assume that the downstream firm cannot contract with the upstream firm over safety, a second contrast with Hay and Spier.<sup>7</sup> Downstream firms do, however, contract over quantity, i.e., purchase from the upstream firm, distinguishing our model from the prior literature on multiple tortfeasors.

The central implication of our model is that, when upstream firms operate in multiple jurisdictions, efforts by a local jurisdiction to impose greater liability on upstream firms may increase output of the hazardous good, a result that runs contrary to all prior models of tort liability.<sup>8</sup> Because the upstream firm operates in multiple jurisdictions, its nationwide precautionary behavior – and thus its supply function – does not change dramatically in response to local tort rules. However, because higher upstream liability reduces the share of liability that flows downstream, the local downstream distributor's demand for the hazardous upstream product increases. The perverse result is higher equilibrium output of the risky good in a local jurisdiction that imposes stricter tort liability upstream.

From a normative point of view, the presence of multiple jurisdictions undermines the typical welfare logic of tort rules. With a single, uniform legal regime, the upstream firm passes on its liability costs to the downstream firm. This "pass-through" liability cost plus the downstream firm's own direct liability cost ends up being exactly equal to the total liability associated with the product. In this case, the downstream firm faces exactly the right incentives, and efficiency ensues. However, this logic breaks down when the upstream firm operates in multiple jurisdictions.

With multiple jurisdictions, the upstream firm's liability costs are equal to the market-weighted average liability cost across all jurisdictions. It continues to transmit these costs downstream as before, but in this case, the "pass-through" cost plus the downstream firm's local liability cost may not add up to the true liability, because the market-weighted average liability cost may not be equal to the liability cost in a particular jurisdiction. With multiple jurisdictions, therefore, incentives are aligned only in those jurisdictions where the upstream liability rule is exactly equal to the average liability imposed by all jurisdictions together. States imposing above average upstream liability costs will suffer excessive output of the risky good, because downstream firms will behave too recklessly. In these states, further

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<sup>6</sup> Upstream and downstream firms are assumed to be competitive. The results remain, modulo double marginalization, if the firms have market power (c.f. Polinsky and Rogerson 1983).

<sup>7</sup> In contrast to Spence (1977), we assume consumers do not underestimate (or overestimate) risk, so that mistaken beliefs do not drive inefficiency in our model.

<sup>8</sup> Prior models of tort assume tort liability increases supply costs (e.g., Spence 1977, Landes and Posner 1985, Polinsky and Rogerson 1983). In a prior working paper, however, we show that, if there are transactions costs, higher tort liability can increase demand and thereby increase equilibrium supply (Helland et al. 2011). A contrast between that working paper and the current model is that we explore the relationship between upstream and downstream liability.

increases in upstream liability exacerbate the inefficiency and lead to even more sales of the risky good. In contrast, states with below average upstream liability will face the opposite problem, of underprovision of the risky good.

We test the positive predictions of the theory using data from the U.S. pharmaceutical market. We use punitive damage caps to measure liability on upstream pharmaceutical firms. We show that an increase in upstream punitive damage liability on drug companies lowers the absolute level of liability on downstream doctors.<sup>9</sup> We then find that higher upstream drug liability leads to an increase in prescribing by downstream doctors. However, in states where noneconomic damage caps limit liability for doctors, we find that changing the liability of upstream firms does not affect prescribing by downstream doctors.

Table 1 provides a simple illustration of our main empirical findings. The table reports average drug sales—measured as the number of prescriptions written per outpatient visit—by state according to the products liability and malpractice liability regimes.<sup>10</sup> States with higher products liability for upstream drug manufacturers have 2.3% more drug prescriptions per visit as compared to states with lower liability exposure for manufacturers.

Closer inspection reveals that this increase is driven by the subset of states where liability is shared across doctors and drug companies, rather than by the states in which liability is targeted exclusively at drug companies themselves. States that cap malpractice liability for physicians are effectively shifting all, or nearly all of, the liability upstream, without sharing it across the vertical chain of production. Thus, increases in upstream liability have no spillover effects on the liability faced by downstream firms. In these states, higher upstream liability has the expected effect of reducing prescribing by 5.2%. However, among states without caps where liability is shared between drug companies and doctors, greater upstream liability leads to a 7.4% increase in prescription drug utilization. While these results are unadjusted for other factors, we obtain qualitatively similar findings even with a full set of regression controls and various fixed effects specifications.

This result stands in stark contrast with the prior empirical literature on tort liability. A number of studies find that higher tort liability reduces quantity of output (Currie & MacLeod, 2008; Eric Helland, 2008; E. Helland & Showalter, 2009; Kessler, Sage, & Becker, 2005; Klick & Stratmann, 2007; Malani & Reif, 2013; Matsa, 2007). No prior studies find that higher liability is associated with increased output. Moreover, no papers find (or explain) that the effect of higher liability on upstream firms depends on the liability of downstream firms. We find that the spillover effects of liability on upstream firms on downstream firms are an empirically significant phenomenon, at least in the pharmaceutical industry.

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<sup>9</sup> One concern is that higher permissible punitive damages do not merely shift liability from downstream doctors to upstream drug companies, but rather increase liability of both actors. Punitive damages are easier to obtain, however, if the doctor testifies against the drug company. Thus plaintiffs frequently give doctors a break on liability in order to increase the expected punitive award from drug companies. Moreover, doctors rarely pay punitive damages.

<sup>10</sup> The data and methods used to construct the table are described in detail in Section II.

The remainder of the paper can be outlined as follows. Section I presents models of tort liability with vertical production and an upstream firm that operates in multiple jurisdictions. Section II presents our empirical application. We conclude with topics for future research.

## I. Theory

We begin with an upstream firm that produces a hazardous good that it sells to  $N$  different legal jurisdictions. This hazardous good is used as an input by downstream firms. For simplicity, each downstream firm operates in only one market or jurisdiction. The latter assumption does not sacrifice generality so long as downstream firms can set retail prices differentially across jurisdictions in order to reflect different levels of liability risk. Since distributors and retailers typically have some local presence, this assumption seems plausible, and while they cannot always price-discriminate across regions with impunity, a reasonable amount of latitude exists so that different liability costs may be incorporated.

The amount of hazardous input sold in jurisdiction  $i$  is denoted  $x_i$ . As shown in the appendix, it is straightforward to expand the model to include the use of substitutable safe inputs without changing the predictions. Therefore, in the interests of simplicity, we exclude safe inputs from the theoretical presentation here. The hazardous input has marginal cost of production  $c$  and associated input price  $w$ .

We model downstream behavior with a representative firm in jurisdiction  $i$  that produces an output  $y_i = f(x_i)$ , which is sold at the price  $p_i$ . Downstream production is increasing and concave ( $f_x > 0, f_{xx} < 0$ ).<sup>11</sup>

The normative analysis of this problem is most transparent when we consider the case where both the upstream firm and the downstream firm are competitive, because this abstracts from the standard welfare problems associated with monopoly. In the appendix, we work out the case in which the hazardous goods producer is a monopolist and demonstrate qualitatively similar comparative statics.<sup>12</sup>

The upstream hazardous good producer may have different tools at its disposal for managing harms, depending on the nature of the good being produced. Some manufacturers may be able to make direct safety investments in production that reduce the risk to users. One example of this situation is a firm producing consumer goods like clothing and tires. Other manufacturers may be unable to influence the actual safety of the good, but able to warn users about the product's risks. The marketing of pharmaceuticals is a prime example. U.S. tort law addresses the first situation in "design defect" and "manufacturing defect cases" and the second in "failure to warn" cases.

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<sup>11</sup> We consider the allocation of liability between an upstream and downstream firm. However, the model can be extended to the case of a single producer and a consumer, where the consumer's use of the product can harm third parties, as in Hay and Spier (2005).

<sup>12</sup> Normatively, the key difference is that the upstream firm does not pass on the full extent of tort liability to the downstream firm. This will prevent price from ensuring the downstream firm faces the full social cost from use of the hazardous input, increasing the quantity level of that input in equilibrium.

Indeed, the product in our empirical application – pharmaceutical drugs – is legally exempted from design defect liability. Courts have concluded that drugs are inherently unsafe and hold pharmaceutical companies liable only for failure to disclose known side effects to physicians.<sup>13</sup> Therefore, we present a model in which the upstream firm can only warn users about product risks. In the appendix, we provide a model of an upstream firm that can also change the safety of its products.

The harm to consumers in jurisdiction  $i$  from the hazardous input is assumed to be proportional to its utilization in the final product,  $hx_i$ , where  $h$  is a fixed factor beyond the upstream firm's control.<sup>14</sup> Conceptually,  $h$  is the summation of different risks associated with the input. For example, it could be the sum total of harms in the aviation industry associated with aircraft engine failure, body failure, electronics failure, and so on. The upstream firm can choose to report some of these harms, but not others. To capture this, we let the upstream firm choose to report the share  $r$  of these harms.

We make three critical assumptions that govern the harm from the hazardous input. First, we assume the upstream firm sells a common product across jurisdictions, so it cannot customize warnings by jurisdiction. Moreover, we assume a national or global marketplace, so that arbitrage forces it to sell at a common price across jurisdictions. If upstream firms can easily price discriminate across jurisdictions, the multiple jurisdiction problem collapses to the single-jurisdiction model, which behaves in a more standard fashion. However, this price-discrimination is often difficult to achieve, particularly across state lines within the US.

Second, we assume that, while the upstream firm knows the harm from its product, the downstream firm does not. It must infer harm from the tort environment and any disclosures that the upstream firm makes.

Third, we assume that demand for the final output does not depend on the harm  $hx_i$ . This is a common assumption in the literature on products liability. The typical justification is that, if the assumption failed to be true, consumers would be able to observe and contract directly for the level of safety they desire, without products liability rules (Miceli, 1997).<sup>15</sup> This type of contracting or demand behavior is not typically seen, either because safety is not observable at the time of contracting, or because it is costly to negotiate a settlement after the safety of the product is revealed through use. Another possible justification is that consumers have health, life, or property insurance that makes them

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<sup>13</sup> See Restatement (Second) of Torts §402a, cmt. K.

<sup>14</sup> We abstract from dynamic decisions relating to product withdrawal and introduction.

<sup>15</sup> There may be a role where consumers demand heterogeneous levels of safety but there is only one (upstream) producer and it can only supply one level of safety. For example, Choi and Spier (2011) consider the case where safety depends on precautions by a single producer and consumers differ in the probability of being harmed by a product. The firm may choose to lower its precaution in order to select for lower risk consumers much as insurance companies may reduce coverage on a given policy in order to adversely select for lower risk beneficiaries. Non-waivable products liability, like an insurance mandate, stops this selection. Note that the sale of multiple products with different levels of safety and price, as in Hay and Spier (2005), can do the same, though it reduces cross subsidization.



indifferent to the harm. Each of these justifications appears plausible in the pharmaceutical industry, which is the subject of our empirical application.

The total damages awarded by courts in jurisdiction  $i$  are given by  $hx_i$ . Whereas final consumers cannot easily observe product safety, courts – through evidentiary discovery – are able to both observe and punish lapses in safety. This too is a common assumption in the literature on products liability. The amount of total damages captures the legal restriction that damages cannot generally exceed the losses suffered by consumers.<sup>16</sup> Moreover, we assume that damages are split between the upstream firm and the downstream firm in proportions  $a_i$  and  $(1 - a_i)$ , respectively, where  $a_i \in [0,1]$ .

There are two things that influence this allocation of liability between firms. First, the upstream firm's share of tort liability is decreasing in the disclosed share  $r$  of total harms. Since failure-to-warn liability is designed to encourage disclosure, more disclosure reduces liability. Second, state-level tort law can, through various mechanisms, influence the allocation of liability upstream and downstream. For example, damages caps on the upstream firm may make it a less attractive target for suit and reduce the amount of recovery against that firm. The effect of a specific tort doctrine or reform on the apportionment of damages between firms will depend on how precisely it operates.

To capture these two influences, we let the upstream firm's share of damages  $a_i = a(t_i, r)$  depend on the tort parameter,  $t_i \in [0,1]$ , which captures the degree of upstream liability exposure in jurisdiction  $i$  for different disclosure levels  $r$ . Note that tort law may vary across jurisdictions, but a firm's disclosure is constrained to be the same across jurisdictions. Information travels freely and undermines efforts at differential disclosure across jurisdictions. We assume upstream share of liability rises in the tort parameter, i.e.,  $a_{it} > 0$ . Moreover, we assume that the upstream firm's share of liability  $a$  is decreasing in the share of harms it discloses:  $a_r < 0$ . We also assume disclosure, if anything, relieves greater tort liability the higher is that tort liability, i.e.,  $a_{tr} \leq 0$ .

We do not explicitly model the disclosure game that upstream and downstream firms play, and thus the inferences that the downstream firm draws from an upstream firm's disclosure signal. A specific disclosure game would limit the generality of the analysis, since there are many plausible ways to specify the disclosure game and off-path beliefs.

Instead, in order to keep the analysis simple and at a price-theoretic level, we do two things. First, we presume that the upstream firm fails to disclose all the hazards associated with its product. As we show later, this assumption implies that downstream firms will believe a good is riskier when the upstream firm discloses more harms. Second, we assume that, whatever game firms play, downstream firms update their beliefs about product hazards purely on the basis of upstream firm disclosures, and not the tort law regime per se. In other words,  $E[h|t', rh] = E[h|t'', rh] \forall t', t''$ , where  $E[h|t, rh]$  reflects the downstream firm's inference about the hazards of the upstream output given tort law and upstream disclosure.

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<sup>16</sup> An exception is punitive damages, a topic we will take up in the empirical section.

Our approach rules out complex effects of the policy configuration on downstream firm beliefs. However, it captures the first-order effects of disclosure and allows us to analyze the impact of tort law on market outcomes and even welfare without specifying a very particular information game between the upstream and downstream firms.

### A. Homogenous legal environment

To begin we consider the simple setting in which both the upstream and downstream firms face a homogeneous legal environment, i.e., the upstream firm operates in a number of jurisdictions but a single liability regime governs all those jurisdictions. The main implication of the common liability regime is that the upstream firm's share of liability is identical across jurisdictions, i.e.,  $t_i = t$  and  $a_i = a(t, r) \forall i$ . We will show that in this environment, the allocation of liability upstream and downstream affects market outcomes only by influencing the disclosure behavior of the upstream firm.

**Upstream firm.** The hazardous good producer chooses its disclosure to maximize profits net of tort liability across jurisdictions indexed by  $j$ :

$$\max_r \sum_j x_j(r)(w - c - a(t, r)h)$$

Downstream demand  $x_j(r)$  only depends on upstream disclosure, because we assumed upstream disclosure is the only variable that directly affects downstream inferences about the safety of the hazardous input. In order to focus on the realistic and non-trivial case where liability rules matter, we assume that downstream demand falls in the degree of safety disclosures, i.e.,  $x_j' < 0$ . If this were not the case, then the upstream firm would always fully disclose, and there would be no reason for failure-to-warn liability.

Competition ensures the hazardous input price is equal to the upstream firm's marginal cost:  $w = c + ah$ . This implies that the upstream firm passes through to the downstream firm its cost of bearing liability risk for non-disclosed harms.

Profit-maximization implies that the firm's disclosure balances the reduction in demand against the reduction in tort costs:  $(w - c - ah)\sum_j x_j' - a_r h \sum_j x_j = 0$ , where we have suppressed the arguments of  $x_j$  and  $a$ . Given an internal optimum, comparative statics imply that an increase in the upstream tort parameter causes the upstream firm to disclose more risks:

$$\frac{\partial r^*}{\partial t} = \frac{-a_t h \sum_j x_j' - a_{rt} h \sum_j x_j}{-SOC} > 0,$$

where  $SOC < 0$  is the second order condition. There are two reasons for this. According to the first term in the numerator, higher tort exposure reduces net revenue and thus the cost of losing sales due to disclosure. According to the second term in the numerator, higher tort exposure also (weakly) increases the tort-related savings from disclosure. Both effects encourage disclosure. Conversely, higher downstream liability discourages disclosure because it reduces the upstream firm's tort exposure for failure to disclose.

**Downstream firm.** The downstream firm in an arbitrary jurisdiction  $i$  maximizes revenue net of input and tort costs:

$$\max_{x_i, z_i} p_i f(x_i) - (w + E[(1 - a(t, r))h|t, r^*h])x_i$$

where  $E[(1 - a(t, r))h|t, r^*h]$  is the downstream firm's expectation about the tort damages it faces. By law, these damages are the residual of health harms not allocated to the upstream firm. These damages will depend on the tort law  $t$ , the upstream firm's equilibrium level of disclosure  $r^*$  and how these elements affect the upstream firm's allocation of liability  $a(t, r)$ , each of which is known to the downstream firm.

The profit-maximizing input usage is given by

$$pf_{x_i} = w + E[(1 - a(t, r))h|t, r^*h]$$

To determine how a change in the upstream liability affects downstream behavior, we first substitute in the equilibrium price of the hazardous input,  $w = c + ah$ . When doing so, we assume that the downstream firm knows everything in the upstream firm's objective function except  $h$ , i.e., it knows the shape of demand  $x(r)$  and marginal costs  $c$ . It also knows that the upstream firm is liable for fraction  $a$  of total harm to the consumer, and that it is liable for fraction  $1 - a$  of that harm. Finally, it knows the total harms disclosed by the upstream firm,  $r^*h$ , although it can only guess at undisclosed harms.

We find that the downstream firm's full input price does not directly depend on the allocation of liability across firms:

$$w + E[(1 - a)h|t, r^*h] = c + E[ah|t, r^*h] + E[(1 - a)h|t, r^*h] = c + E[h|t, r^*h]$$

The full "pass-through" of the upstream firm's liability to the downstream firm yields this result. In other words, the downstream firm internalizes the full measure of liability, regardless of the sharing rule.

Further, our assumptions relating to downstream inferences about product safety imply that  $E[h|t, r^*h] = E[h|r^*h]$ . Therefore, the optimal input usage expression can be rewritten as:

$$pf_{x_i} = c + E[h|r^*h] \tag{1}$$

The downstream firm only cares about the upstream firm's marginal cost and expected health harm per unit of the hazardous input – as inferred from the upstream firm's disclosure – because the upstream price passes on any fraction of liability that the downstream firm does not directly bear.<sup>17</sup>

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<sup>17</sup> If the upstream firm were not in a competitive market, its price would not pass on its entire share of liability. In that case the downstream firm's full marginal cost of using the hazardous input would depend on directly on the tort allocation.

As mentioned earlier, we do not model the disclosure game that the upstream and downstream firms play. However, we instead demonstrate the implications of the (realistic) scenario in which the upstream firm fails to disclose all health hazards. In this case, additional disclosures will necessarily cause the downstream firm to infer that the product is riskier than previously believed, or that  $E[h|r'h] > E[h|r''h]$  for some  $r' > r''$ .

To demonstrate this result, suppose, for simplicity, that  $E[h|r^*h]$  is continuous in  $r^*$ . Comparative statics with respect to disclosure implies that

$$\frac{\partial x_i}{\partial r^*} = \frac{\partial E[h|r^*h]}{\partial r^*} \frac{1}{pf_{xx}}$$

In order for the upstream firm not to disclose all health hazards, there must be a cost to disclosure. Specifically, downstream demand must fall with disclosure, i.e.,  $x'(r) < 0$ . Moreover,  $f_{xx} < 0$  by assumption. Therefore, it must be that  $\partial E[h|r^*h]/\partial r^* > 0$ , i.e., greater disclosure must be associated with an expectation of greater harm.

The input price passes through the hazardous goods producer's tort liability cost. Essentially, the market price aligns the safety incentives of the upstream and downstream firms, so that only total liability matters, not the share imposed on each firm. This implies that that allocation of liability only affects downstream demand for the hazardous good *indirectly*, through its effect on upstream disclosure. Concretely, higher upstream liability leads to more disclosure, which then leads downstream firms to infer greater hazards and correspondingly limit their demand. The following proposition summarizes these findings.

**Proposition 1.** *Suppose the upstream firm cannot affect the safety of a product, the upstream firm has chosen an interior value for disclosure, and the downstream firm has chosen interior values for the hazardous input. In a homogenous legal environment, a change in tort parameters that increases upstream liability share  $a$  will cause the downstream firm in each jurisdiction  $i$  to decrease use of the hazardous input and its output  $y_i$ .*

The socially optimal liability rule results in efficient input usage. Since the social marginal cost of the hazardous input is  $c + h$ , equation (1) implies that efficiency obtains when  $E(h|r^*h) = h$ , or when the downstream firm makes the correct inference about expected risk. The following proposition summarizes this logic.

**Proposition 2.** *Under the assumptions of Proposition 1, a sufficient condition for a liability allocation,  $a$ , to be first best is that, given the allocation, the upstream hazardous good producer's disclosure is such that the downstream firm correctly infers the health risk of from the hazardous good, i.e.,  $E[h|r^*h] = h$ .*

Note that a liability rule that falls short of assigning all liability to the upstream firm may be adequate if it is nonetheless able to ensure correct downstream inferences. This is true even in the absence of complete disclosure.

The results above rest critically on our assumption of a homogenous legal environment. In the next subsection, we will show that, in a heterogeneous legal environment, upstream liability is not perfectly passed through to the downstream firm. As a result, the allocation of liability will have direct effects on downstream input choices, not just indirect effects that operate through disclosure. These direct effects can have perverse consequences, as we will see.

## B. Heterogeneous legal environment

Now consider the case where liability rules vary across jurisdictions, i.e.,  $t_i \neq t \forall i$ . The upstream and downstream firm's objective functions remain the same as in the homogenous legal environment, except that we replace  $t$  with  $t_i$  in the liability share function  $a$ . Unlike in the homogeneous case, the actions of a single isolated jurisdiction will have limited effects on disclosure behavior. However, they will influence the degree of risk-taking that the downstream firm engages in.

**Upstream firm.** The upstream firm's objective is

$$\max_r \sum_j x_j(r) (w - c - a(t_j, r)h)$$

Upstream competition ensures price passes on the *average* upstream tort liability:  $w = c + \bar{a}h$ , where  $\bar{a} = \sum_j a(t_j, r)x_j(r)$  is the weighted average of the upstream firm's liability allocation across jurisdictions where the weights are sales in each jurisdiction. As in the homogenous case, the firm's optimal disclosure policy  $r^{**}$  balances the reduction in demand against the reduction in average tort costs. However, an increase in, say, the upstream liability parameter in jurisdiction  $i$  encourages disclosure much less than an increase in the upstream liability parameter in all jurisdictions. To see this, observe that:

$$\frac{\partial r^{**}}{\partial t_i} = \frac{-x'_i a_{i,t} h - x_i a_{i,rt} h}{-SOC} > 0, \forall i$$

This effect of jurisdiction  $i$ 's tort law on disclosure is positive, as are the corresponding effects of each independent jurisdiction  $j$ . Therefore, it follows that adding up the effects of tort changes across the individual jurisdictions will magnify the total effect on disclosure, or that:

$$\frac{\partial r^{**}}{\partial t_i} = \frac{-x'_i a_{i,t} h - x_i a_{i,rt} h}{-SOC} < \sum_j \frac{\partial r^{**}}{\partial t_j}, \quad (2)$$

where  $SOC < 0$  is now the upstream firm's second order condition in the heterogeneous legal environment. In the limit, as the share of jurisdiction  $i$  in total output goes to zero, an increase in upstream liability will have no effect on disclosure.<sup>18</sup>

**Downstream firm.** The downstream firm's objective is

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<sup>18</sup> Since disclosure  $r$  is bounded in  $[0,1]$ , we know that the change in  $\sum_j \partial r^{**}/\partial t_j$  must also be bounded. As  $\sum_{-i} x_j \rightarrow \infty$ , the ratio of  $\partial r^{**}/\partial t_j$  to  $\sum_j \partial r^{**}/\partial t_j$  must go to zero for (2) to hold.

$$\max_{x_i} p_i f(x_i) - (w + E[(1 - a(t_i, r^{**}))h|r^{**}h])x_i$$

After plugging in the upstream firm's prices into the first-order condition from this problem, the optimal input usage for the downstream firm satisfies:

$$pf_{x_i} = c + E[\bar{a}h|r^{**}h] + E[(1 - a_i)h|r^{**}h]$$

An empirically important difference between this condition and the analogous condition for a homogenous legal environment is the upstream price passes on the *average* upstream share of liability rather than just the upstream share of liability in jurisdiction  $i$ . As a result, the input price does not perfectly transmit the effects of upstream liability to the downstream firm. This creates misalignment in the incentives of the downstream firm, which no longer internalizes the exact social harm associated with the product.

Because of this misalignment, the allocation of liability is no longer neutral. Even when the downstream firm makes correct inferences about risk, i.e.,  $E[h|r^{**}h] = h$ , it still might not be acting in a socially optimal manner, because it might be facing private costs of liability that are higher or lower than social costs. Specifically, if the upstream firm's share of liability in jurisdiction  $i$  is higher than average, then the downstream firm will face less than the full health cost of the hazardous input and will demand too much of that input relative to the social optimum. The opposite problem obtains for jurisdictions with upstream liability shares that are lower than average.

Comparative statics imply that the effect of an increase in upstream tort allocation in jurisdiction  $i$  on output is

$$\frac{\partial x}{\partial t_i} = \frac{1}{pf_{xx}} \left[ \left\{ \left( \frac{\partial \bar{a}}{\partial t_i} - \frac{\partial a_i}{\partial t_i} \right) + \left( \frac{\partial \bar{a}}{\partial r^{**}} - \frac{\partial a_i}{\partial r^{**}} \right) \frac{\partial r^{**}}{\partial t_i} \right\} E[h|r^{**}h] + (\bar{a} + (1 - a_i)) \frac{\partial E[h|r^{**}h]}{\partial r^{**}} \frac{\partial r^{**}}{\partial t_i} \right]$$

(Recall that we assume tort law affects behavior only through its effect on disclosure.) The sign of the above effect is uncertain. While additional tort liability in jurisdiction  $i$  surely has positive direct effects on upstream liability ( $\partial \bar{a} / \partial t_i > 0$ ), it has negative indirect effects that operate through disclosure ( $(\partial a_i / \partial r^{**})(\partial r^{**} / \partial t_i)$ ).

However, as the upstream firm operates in more and more jurisdictions beyond  $i$ , the effect becomes clearer. In the limit, as  $X = \sum_{-i} x_j \rightarrow \infty$ , the effect of a single jurisdiction's actions on average liability goes to zero, so that  $\lim_{X \rightarrow \infty} \partial \bar{a} / \partial t_i = 0$ . At the same time, the effect of a single jurisdiction's tort rules on the upstream firm's disclosure decision also goes to zero, so that  $\lim_{X \rightarrow \infty} \partial r^{**} / \partial t_i = 0$ . For this limiting case, higher upstream liability in jurisdiction  $i$  results in greater use of the hazardous input:

$$\frac{\partial x}{\partial t_i} = \frac{1}{pf_{xx}} \left( -\frac{\partial a_i}{\partial t_i} E[h|r^{**}h] \right) > 0$$

In this case, more stringent tort law in one jurisdiction has no effect on upstream disclosure, or on the global average liability regime. It does not even affect the price of the hazardous input, which remains

at  $c + \bar{a}h$ . Its only effect is to shift liability away from the downstream firm and discourage precaution by that firm. This stands in contrast to the result in a homogenous legal environment. This logic yields the following proposition.

**Proposition 7.** *Suppose the upstream firm cannot affect the safety of a product, the upstream firm has chosen an interior value for disclosure, and the downstream firm has chosen interior values for the hazardous input. In a heterogeneous legal environment, an increase in the upstream tort parameter  $t_i$  tends to increase the downstream firm's use of the hazardous input  $x_i$  and downstream output  $y_i$  as the output share of jurisdiction  $i$  falls to zero.*

From a normative perspective, the first best is achieved when the downstream faces the full social cost of the use of the hazardous input. This occurs when (a) the upstream firm's liability from jurisdiction  $i$  is fully passed through to the downstream firm, i.e.,  $a_i = \bar{a}$  and (b) the upstream firm's disclosure causes the downstream firm to make a correct inference about the risks of the hazardous input, i.e.,  $E[h|r^*h] = h$ . The first condition is certainly met in all jurisdictions when liability rules are uniform. It is also met for the jurisdiction that sets its rules equal to the societal average liability,  $\bar{a}$ . The necessity of the first condition also implies that even when the downstream firm's inference is correct, if the upstream share in jurisdiction is more than the average liability, the downstream firm does not face the full social cost of the hazardous input. This yields the following proposition.

**Proposition 8.** *Under the assumptions of Proposition 7, the first best is achieved if the tort parameter  $t_i$  in jurisdiction  $i$  causes (a) the downstream firm to make correct inferences from the upstream firm's disclosure and (b) the upstream share of liability in the jurisdiction to be the same as the average share of upstream liability across all jurisdictions. Suppose condition (a) is met, but not condition (b). If the tort law parameters cause upstream share in jurisdiction  $i$  to be greater (less) than average upstream share, then the downstream firm will use more (less) of the hazardous input  $x_i$  and produce more (less) output  $y_i$  than is socially optimal. Moreover, as the output share of jurisdiction  $i$  falls to zero, a change in tort law that causes upstream share to rise in jurisdiction  $i$  with above average upstream liability share  $a_i$  will reduce (increase) both welfare in jurisdiction  $i$  and global welfare.*

**Proof.** See appendix.

Intuitively, downstream firms internalize true social cost only when their jurisdiction's liability rules match the average liability share that the upstream firm perceives. In contrast, jurisdictions with higher than average upstream liability are encouraging inefficiently reckless behavior by downstream firms. In such jurisdictions, further increases in upstream liability exacerbate this inefficiency and make the jurisdiction worse off.

Global welfare across all jurisdictions differs from local welfare, because additional liability in jurisdiction  $i$  may cause additional disclosure that benefits other jurisdictions. However, this effect diminishes as the output share of jurisdiction  $i$  falls. Moreover, if liability rules are such that downstream firms in other jurisdictions already make correct inferences about the risks of the hazardous input, this spillover benefit is nil.

## II. Empirical analysis

### A. Empirical predictions

Proposition 7, which examines the case where firms cannot improve the safety of a products and jurisdictions have heterogeneous legal regimes, makes a number of straightforward empirical predictions.

1. Holding upstream liability fixed, increases in liability faced by the downstream firm will lead to less output in a jurisdiction, i.e.,  $\frac{\partial x_i}{\partial t_i} dt_i < 0$ , when  $\frac{\partial \bar{a}}{\partial t_i} = 0$ ,  $\frac{\partial r^{**}}{\partial t_i} = 0$ , and  $dt_i < 0$ .
2. When individual jurisdictions have minimal effects on the upstream producer's liability expectations, we have two further predictions.
  - a. When downstream and upstream firms share liability, increases in the share of liability faced by upstream firms in a jurisdiction leads to more output in that jurisdiction, i.e.,  $\frac{\partial x_i}{\partial t_i} dt_i > 0$ , when  $\lim_{X \rightarrow \infty} \partial \bar{a} / \partial t_i = 0$ ,  $\lim_{X \rightarrow \infty} \partial r^{**} / \partial t_i = 0$ , and  $dt_i > 0$ .
  - b. When downstream firms are insulated from liability, increases in upstream liability within a jurisdiction lead to no changes in output, i.e.,  $\frac{\partial x_i}{\partial t_i} dt_i = 0$ , when  $\frac{\partial a_i}{\partial t_i} = 0$ ,  $\lim_{X \rightarrow \infty} \partial \bar{a} / \partial t_i = 0$ ,  $\lim_{X \rightarrow \infty} \partial r^{**} / \partial t_i = 0$ , and  $dt_i > 0$ .

Notice that effects 2a and 2b imply that the positive impact of upstream liability on output should be larger when downstream firms share liability than when they do not. Thus, the interaction effect between higher upstream liability and the imposition of liability for downstream firms should be *positive*. This is the novel empirical prediction generated by the theoretical model, and which we test in our empirical analysis.

We study the empirical context of state-level tort rules applied to the pharmaceutical market in the US. The pharmaceutical market is a useful setting to test our model, because it is populated by upstream drug manufacturers that produce drugs and downstream physicians' practices that use drugs as an input in the delivery of health care. Upstream drug manufacturers operate in multiple jurisdictions with different legal environments, which in our application are US states. In contrast, each downstream physician operates in only one state due to state licensing laws. Due partly to arbitrage opportunities and partly to the institutional detail that a small number of pharmacy benefit managers negotiate drug prices for most insurance plans, upstream drug companies sell any given drug at the same price across states and cannot fully control the quantity of sales within each state (Lakdawalla & Yin, Forthcoming). Downstream doctors can control sales within a state because, other than over-the-counter medications, drugs cannot be dispensed without a prescription. Finally, while branded drug manufacturers are not competitive, the Appendix demonstrates how our results generalize with a monopolist firm upstream. Positive and normative results are similar, holding fixed the standard deadweight loss from monopoly.



We use the presence of punitive damage caps on products liability awards as the policy variable that shifts liability from upstream drug manufacturers to downstream physicians. We use the presence of a noneconomic damage cap on medical malpractice awards as the policy variable that imposes liability on downstream physicians.

We begin by describing the various sources of data we use, in Section B. Section C provides background on products liability for pharmaceutical manufacturers, and then provides evidence that punitive damage caps shift liability from upstream drug manufacturers to downstream physicians, and vice-versa. Section D presents and tests some basic assumptions of our identification strategy, and discusses our empirical specification for the tests of the model. Section E presents our results.

## **B. Data**

### **1. Quantity of drug sales**

There is no single, nationally representative source for drug utilization data. We derive measures of the utilization of prescription drugs from a large database of private-sector health insurance claims. These data are drawn from the Touchstone database from Optum, a healthcare consulting firm. We received information on all pharmacy spending and utilization for all covered patients from 1997 to 2007. These data have been used in a number of prior analyses of pharmaceutical drug utilization (Goldman et al., 2004; Goldman, Joyce, Lawless, Crown, & Willey, 2006; Joyce, Escarce, Solomon, & Goldman, 2002).

Using these data, we construct aggregate measures of utilization by drug, state and year. While the Touchstone data track national numbers reasonably well, they are not designed to be a nationally representative sample. To address possible differences in sampling by state over time, we reweight the utilization data so as to be nationally representative by gender and age category. We begin by calculating state-level enrollment in Touchstone by gender, and 8 age categories (0-10, 11-19, 20-29, 30-39, 40-49, 50-59, 60-64, 65+). Next, we use the Current Population Survey (CPS) to calculate total US insured population by state, gender, and age cells.<sup>19</sup> The CPS data are used to weight the Touchstone data and construct total utilization at the drug-state-year level. To normalize prescribing behavior according to population size and utilization of health care, we focus on the number of prescriptions for each drug per 1,000 total outpatient physician visits in a state and year.<sup>20</sup>

### **2. Tort liability rules**

Our identification strategy relies on legislative changes that impact expected tort liability separately for upstream manufacturers and downstream doctors. Our primary treatment variable for

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<sup>19</sup> The insured population includes individuals covered by private insurance or Medicare. We include Medicare because many of the old insureds in the MIDas data have both private coverage and Medicare.

<sup>20</sup> Note that not every prescription requires a visit to a physician. Some prescriptions could be written at hospitals or in emergency departments. Also, we focus on 30-day equivalent prescriptions, so any refills count as separate prescriptions. So this measure should not be interpreted as the probability that a prescription is filled conditional on a visit.

manufacturer liability comes from caps on punitive damages. Later we argue that these caps affect the share of upstream liability relative to downstream liability. We proxy for expected punitive damages liability using a variable that is set to zero if a state statute caps punitive damages and one otherwise. Thus we interpret our treatment variable as legislation that creates high products liability within a state. Similarly, we use noneconomic damage caps as shocks to the medical malpractice liability of doctors.<sup>21</sup> Our treatment variable for downstream doctor liability is set to zero if a state has a damage cap in place and one otherwise; it can be interpreted as the presence of high malpractice liability.

The data on legislative reforms come largely from Avraham's data (2012) on tort reform. In the case of punitive damages, we utilize only legislative changes that apply to products liability. Since Avraham's data focus primarily on medical malpractice litigation, we supplemented these data with our own search using online sources such as the archives of the American Tort Reform Association.

Table 2 describes the legislative changes that occurred during the timing of our study sample. During our sample period six states (AL, AK, AR, ID, MS, MO, and OH) adopted punitive damage caps that applied to products liability cases, while two states (PA and IL) repealed caps. During this same time period, 8 states (FL, GA, IL, MS, NV, OH, OK, TX) adopted non-economic caps for medical malpractice cases.

### **3. Drug characteristics**

In our regression analyses, we control for other characteristics of drugs that could relate to sales. These include the generic status of the drug, as well as the number of generic competitors within the same therapeutic class. We use the 2007 Red Book<sup>22</sup> to provide information on generic status and therapeutic class by drug. Broadly speaking, the therapeutic class is a means for grouping drugs according to their use in clinical settings (e.g., "beta blockers"). Our data included 74 different therapeutic categories.<sup>23</sup> To construct the number of generic competitors, we sum across drugs within class for all the drugs in our sample by year.

While generic drugs are older on average, the age of a drug could have an independent effect on demand. Older drugs have more established track records of real-world use, potentially generating more information on safety or real-world efficacy that cannot be gleaned from clinical trials of a few thousand patients. We use information on a drug's age, defined as current year minus the year of approval, which we obtain from the Food and Drug Administration's (FDA) Orange Book database.

Finally, we also use information on black box warnings on the package inserts of prescription drugs. "Black box warnings" represent official disclosures from the manufacturer of adverse event risks.

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<sup>21</sup> We focus on noneconomic damage caps because these reforms are generally found to have the strongest and most robust impact on expected liability (c.f., Danzon, 1982; 1986; Sloan et al., 1989; Waters et al., 1990).

<sup>22</sup> The Red Book™ is a database on pharmaceutical products published by Truven Health Analytics that includes a comprehensive set of identifiers on all brand, generic and over-the-counter products linking information on

<sup>23</sup> This includes a category in which we pooled together relatively rare drugs where there were insufficient observations to include class fixed effects separately (about 5% of drugs fell in this category).

If manufacturers disclose safety risks in the form of trial or other data, the FDA may choose to require the issuance of a black box warning for the drug. Data on black box warnings were gathered by hand from archived MedWatch reports available on the FDA website. Our black box warning data cover the warnings in effect between 1996 and 2009.

Table 3 summarizes the quantity and other drug utilization statistics. In total, we have data on up to 1,227 drugs for up to 10 years in 50 states and the District of Columbia. Since some drugs are introduced or withdrawn from the market during the sample, we end up with 510,969 observations (approximately 8 years per drug per state). There are about 1.8 prescriptions per 1,000 visits on average, with an average price per prescription of about \$198. The share of observations with high products liability and high malpractice liability is almost the same, about 60%, but this masks considerable variation across states. About 22% and 24% of observations are states and years with only high products liability or malpractice liability, respectively, and 36% of observations have both.

#### **4. Products liability and medical malpractice liability**

We employ data on actual liability payments by drug manufacturers and physicians, in order to investigate how our tort policy variables affect upstream versus downstream liability. We gathered data on drug litigation from the LexisNexis book *Guide to Drugs in Litigation*. This book, commonly referred to as the “Grey Book,” is updated annually and covers all drug suits in LexisNexis’s extensive database of litigated cases. Like all publicly available litigation data, its sample frame is limited to cases that go to trial and generate a written opinion and/or trials and settlements discussed in other public sources.

Our data on physician malpractice liability payments come from the National Practitioner Data Base (NPDB). The NPDB is a nationwide database of payments in malpractice cases and includes payments that result from settlements and plaintiff wins at trial. The database contains information on over 200,000 medical malpractice payments made on behalf of practitioners in all 50 states and the District of Columbia.<sup>24</sup> We aggregate these data to the state-year level. We employ data from the period 1992 to 2007 in our analysis.<sup>25</sup>

### **C. Background on products liability and punitive damages for pharmaceutical manufacturers**

#### **1. Failure-to-warn liability in pharmaceuticals**

Drug companies are exposed to products liability primarily through failure to warn suits, which subject companies to damages if they fail to disclose to physicians all drug side effects about which they should have known. Drug companies are not subject to design defect liability, because courts believe that drugs are inherently unsafe and companies cannot reformulate them to eliminate side effects

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<sup>24</sup> These data have been used for research many times and are discussed in more detail elsewhere (c.f., Chandra, Nundy, & Seabury, 2005; Eric Helland, Klick, & Tabarrok, 2005; Eric Helland & Lee, 2010).

<sup>25</sup> The NPDB is the most comprehensive, publicly available database on malpractice claims, but also has some problems with incomplete reporting (Government Accounting Office, 2000). However, for our purposes it is important to note that it is unlikely these reporting issues would be differentially affected across states or across types of claims (e.g., medication-related or other).

(Restatement (Second) of Torts, §402A, comment K). Drug companies occasionally face liability for defects that arise during the manufacturing of a drug. Such cases are not thought to create significant liability, however, because the Food and Drug Administration (FDA) regulates companies' manufacturing processes, reducing the frequency of manufacturing defects.<sup>26</sup>

There are several indications that products liability is an important cost of production for pharmaceutical manufacturers. Products liability is a primary driver of the pharmaceutical industry's legal liabilities (Viscusi, 1991). In Table 4, we summarize information from the LexisNexis Drugs in Litigation reports (the so-called "Grey Book") from 1990-2009. We abstracted data from 665 trials. The average award in this sample was \$6.49 million. When a damage award was granted, the average award was \$15.85 million (approximately 41% of cases involved a damage award). Note that these numbers reflect only a fraction of the total costs of products liability to pharmaceutical manufacturers, as the vast majority are paid in out-of-court settlements and are not included in these figures. Also note that, in contrast to doctors, who purchase liability insurance against medical malpractice cases, drug companies are typically self-insured against products liability.

## **2. Sharing of liability between physicians and manufacturers**

We rely on the idea that punitive damage caps lower the share of liability faced by upstream manufacturers. The crux of our argument relies on the position of a physician in drug safety litigation. In particular, when drug manufacturers face greater liability, they are more attractive targets for litigation, and it is more valuable to secure the cooperation of a physician to testify against the manufacturer. As such, punitive damage caps reduce the absolute liability faced by upstream manufacturers and make it less likely that doctors will be able to avoid liability themselves. In this manner, they reduce both the level and share of liability faced by manufacturers. Here, we flesh out the institutional details that underlie this argument.

Although punitive damages are relatively uncommon, they are frequently responsible for the largest verdicts in products liability (Eisenberg et al., 2006), and they are an important source of liability in failure-to-warn suits against pharmaceuticals. Table 4 shows that \$1.37 million (21%) of the average award in all pharmaceutical products liability cases were for punitive damages. Punitive damages are only granted in 4% of cases and 11% of cases with an award, but when they are granted, they average \$43 million.

Doctors and pharmaceutical manufacturers share liability in failure-to-warn drug cases for several reasons. First, the doctor's presence as a defendant allows plaintiffs to sue in state court. The doctor is local, but the drug company is often out of state. Therefore, suing the company directly would give rise to diversity jurisdiction and move the case to federal court (Willig, 1985). Second, a failure to warn case hinges on doctor's testimony. Because the doctor is a so-called "learned intermediary," the

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<sup>26</sup> For our empirical analysis, our predictions about the impact of liability on the quantity of drugs sales will be the same regardless of whether the source of liability is from failure to warn or manufacturing defects, though the predictions about the impact on safety could differ.

adequacy of the warning depends on what the doctor knew rather than what the patient knew. If the doctor is named as a defendant, his or her best strategy is fairly clear: The doctor will argue that the drug's warning was not sufficiently clear to prevent injury. This would absolve the doctor of responsibility, but would make liability more likely for the drug manufacturer.<sup>27</sup>

These conflicting defenses set up a possible commonality of interest between doctors and plaintiff's attorneys in cases involving pharmaceuticals. A doctor's liability for malpractice is effectively capped at their insurance policy limit (usually \$1 million or less for a specific incident). Thus, compensatory damages are about the most a plaintiff can get from individual doctor. Moreover, winning any amount for a doctor is very difficult and costly. Approximately 80% of malpractice claims against physicians result in no payment for a plaintiff (Jena et al., 2011).<sup>28</sup> Moreover the doctor's testimony is often required to be able to win punitive damages (Willig, 1985). Thus the most direct path to success in a pharmaceutical product liability cases is to either to let the doctor out of liability altogether in exchange for testimony or to reduce the portion of the compensatory and non-economic damages the doctor must pay in the settlement.<sup>29</sup> This argument appears to be confirmed by our review of the Grey Book data, where 56% of cases involved a doctor named as a co-defendant (Table 4).

In our empirical tests, we use punitive damage caps as exogenous shocks to manufacturer liability that (1) reduce the expected liability of manufacturers and (2) transfer that liability to increase the expected liability for physicians. For this approach to be reasonable, we need to establish that punitive damage caps indeed result in both these effects. The impact of punitive damages caps on expected products liability is relatively straightforward to see. For example, in 2005 a jury in Texas found Merck & Co. liable for a the death of a man who took the painkiller Vioxx and awarded his widow more than \$250 million, the vast majority of which came from punitive damages.<sup>30</sup> However, even at the time at which the verdict was awarded, it was widely understood that the plaintiff would be able to receive no more than \$26 million, because of the presence of a cap on punitive damages in Texas. Because punitive damage awards represent a significant share of the large "blockbuster awards," and the threat

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<sup>27</sup> For example, a doctor could argue that the manufactures promotion was unclear about risk or not mentioned by drug reps. It has long been established drug companies have a duty to warn of potential adverse reactions in detailing see *Yarrow v. Sterling Drug, Inc.* 263 F. Supp. 159 (D.C.S.D. 1967).

<sup>28</sup> Despite this, physicians still report high levels of fear and anxiety over malpractice liability risk (Carrier et al., 2010), possibly because of the long and costly process for resolving a claim irrespective of outcome (Seabury et al., 2013).

<sup>29</sup> Deals in which the plaintiff and a defendant reach a secret agreement to reduce one defendants damages at the expense of another are so common that there name for them in product liability. They are called Mary Carter agreements after the defendant in the case *Booth v. Mary Carter Paint Co.* 226 Cal. App. 2 d 8 (Fla. Dist. Ct. App. 1967.) Typically in drug cases the doctor remains a defendant to avoid diversity and testifies as an adverse witness without admitting personal liability.

<sup>30</sup> See [http://www.nbcnews.com/id/9006921/#.Up5B\\_8RDuSo](http://www.nbcnews.com/id/9006921/#.Up5B_8RDuSo), accessed December 1, 2013.

of these can be important tools for settlement negotiations, caps on punitive damages likely have an impact on expected liability far beyond just their direct effect on verdict awards.<sup>31</sup>

The second part of our argument, that punitive damage caps divert liability away from manufacturers and on to doctors, is more nuanced. An increase in punitive damages does not formally, under law, reduce the damages that could be borne by downstream firms. However, the argument above suggests how punitive damage caps can influence the share of compensatory damage awards across parties. If the plaintiff offers to settle with the doctor for more reasonable terms in return for the doctor's testimony against the drug company, then the plaintiff can negotiate a larger settlement than they otherwise would have gotten from the drug company because they can credibly threaten the prospect of punitive damages. Capping punitive damages reduces the plaintiff's leverage against the manufacturer, thus giving them less incentive to settle more favorably with the doctor.

Using malpractice awards data from the NPDB, we can empirically test this hypothesis that punitive damage caps shift liability from the manufacturer to the physician. Let  $D_{pijt}$  represent the malpractice damage award in case  $p$  that occurred in state  $i$  that involved an alleged error type  $j$  in year  $t$ . For our purposes, the key distinction is between damage awards for cases with medication error, as opposed to other types of medical errors. We estimate the regression model:

$$D_{pijt} = \alpha_i + \alpha_j + \alpha_t + \theta_U L^U_{it} + \theta_D L^D_{it} + \theta_{Uj} \alpha_j \times L^U_{it} + \alpha_X X_{it} + \epsilon_{pijt}$$

The regression model includes fixed effects for state, error type and year, as well as a vector  $X$  of other characteristics of the state in which the case occurred (including the fraction male, the fraction nonwhite, income per capita and the share of the population in 5-year age ranges). The policy variables are the tort rules  $L_{it}$  in state  $i$  at time  $t$ . We consider separate tort rules that impact the upstream manufacturer ( $L^U$ ), the downstream physician ( $L^D$ ) and the interaction between the two ( $L^U \times L^D$ ). These can be interpreted as "high products liability," "high malpractice liability" and "high products liability and high malpractice liability," respectively.

The key variables of interest are the liability rules  $L^U$  and  $L^D$ . While we expect the downstream liability rule  $L^D$  to affect damages in all cases, we expect that the upstream liability rule  $L^U$  should have no effect on its own, except to offset downstream liability in cases that involve medication errors. Thus, we interact  $L^U$  with  $\alpha_j$  and test for the differential effect of the products liability regime in cases involving medication errors. Together, we expect that  $L^U = 0$ ,  $L^D > 0$  and  $\theta_{Uj} < 0$ .

Results of this regression are reported in Table 5. The first two rows report the effects of high products liability and high malpractice liability, respectively, on the log malpractice payment per case, where malpractice payments data are taken from the NPDB. The third row reports the interaction term between products liability and cases involving medication errors, while the fourth reports the predicted

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<sup>31</sup> Some of the effect of caps on damage awards could be muted if they simply supersede adjustments that would be made anyway (e.g., reductions on appeal). Nevertheless, appeals are time consuming and costly, so even a reduction that occurs sooner will result in lower expected costs.

effect of products liability rules in medication errors. As we expect, we find that high malpractice liability regimes are associated with higher average payments across all specifications. Our findings also confirm that high products liability regimes have no direct effect on medical malpractice liability. However, when we focus on the effect of high products liability regimes in cases involving medication errors, we find that increasing upstream liability – reflected by the absence of a punitive damage cap -- reduces downstream liability on physicians by 13-14%. These results help confirm the validity of using punitive damage caps as shocks that shift liability from upstream manufacturers to downstream physicians.

#### D. Empirical strategy

We test the effects of state liability rules using a difference-in-difference design that compares drug sales in a state that changes liability rules from year  $t$  to  $t+1$  to a state that does not change during that span. Let  $Y_{gict}$  represent the sales of drug  $g$  in state  $i$  in year  $t$ , where drug  $g$  is a member of therapeutic class  $c$ . Our regression specification is

$$Y_{gict} = \gamma_g + \gamma_i + \gamma_t + \beta_U L^U_{it} + \beta_D L^D_{it} + \beta_{UD} L^U \times L^D_{it} + \gamma_M M_{ct} + \gamma_G G_{ct} + \gamma_X X_{gct} + \epsilon_{igct} \quad (3)$$

The regression includes fixed effects for drug ( $\gamma_g$ ), state ( $\gamma_i$ ), and year ( $\gamma_t$ ). The treatment variable is the tort rule  $L_{it}$  in state  $i$  at time  $t$ . We consider separate tort rules that impact the upstream manufacturer ( $L^U$ ), the downstream physician ( $L^D$ ) and the interaction between the two ( $L^U \times L^D$ ). These can be interpreted as “high products liability,” “high malpractice liability” and “high products liability and high malpractice liability,” respectively.

The coefficients  $\beta_U$ ,  $\beta_D$  and  $\beta_{UD}$  represent our test of the model of liability with vertical production. From the theory, we expect that high malpractice liability should reduce sales, because prescriptions subject physicians to liability risk (so  $\beta_D < 0$ ). We expect that high products liability should increase sales because it shields physicians from liability and removes the disincentives against prescribing (so  $\beta_U > 0$ ). Finally, we expect that this shielding effect of products liability should be strongest when physicians are subjected to the most risk, so we expect (so  $\beta_{UD} > 0$ ). Absent the liability spillovers from vertical production, we might still expect high malpractice liability to lower sales if drugs are considered potentially risky products, but we would not expect to find positive effects of products liability. If anything, absent the liability spillovers we would expect higher products liability to reduce sales by increasing costs.

It might also be true that “failure-to-warn” liability risk is mechanically higher, when manufacturers have indeed failed to warn. As a result, it is plausible that drugs with a greater share of disclosed safety risks will face more muted effects of liability rules on liability risk and on output. We test this hypothesis by stratifying our estimates for drugs with and without black box warnings, which represent officially disclosed safety risks. We then estimate  $\beta_U$ ,  $\beta_D$  and  $\beta_{UD}$  separately in both samples.

In addition to the fixed effects and liability indicators, our empirical model controls for the effect of competition by including the number of branded competitor drugs ( $M_{ct}$ ) and the number of generic competitor drugs ( $G_{ct}$ ) in the same therapeutic class  $c$ . Note that drugs are nested within classes, so we

do not include separate fixed effects for class. Finally, the regression equation includes various controls  $X_{gct}$  to address measurement issues and potential confounders.

Our liability shocks occur at the state level, so it is important to allow for correlation in the error terms across states (i.e., clustering). However, we also observe the same drug across states and years, and it is unlikely that the error terms are independent across drugs. Therefore, we estimate standard errors using the two-part clustering approach of Cameron, Gelbach and Miller (2011) to allow for clustering across states and therapeutic classes. Because drugs are nested within class, this approach allowed for a more flexible combination of possible correlations.

An important identifying assumption for this approach to provide valid estimates is that the adoption of tort reform is exogenous with respect to the pharmaceutical market in a state. This concern is mitigated by a free-rider problem across states. Since drugs are sold on a national market, any given state has a very limited impact on the profitability of a product, so producers have less incentive to invest lobbying efforts in that state. Moreover, since the punitive damage caps tend to affect all cases, these are more likely to be driven by general business interests than solely pharmaceuticals.

To strengthen our confidence that treatment variables are exogenous, we conduct two sets of validity tests. First we conduct a quasi-balancing test that compares adoption of damages caps across states by various outcome variables measured in the first year of the sample, 1997. The states are first binned into quintiles based on prescriptions per outpatient visit, total number of prescriptions, mean drug price, or outpatient visits in 1997. Then the figure plots the number of states with punitive and non-economic damages caps in each quintile. The findings of these tests are reported in Figure 1. Each outcome variable is reported in a separate panel. Importantly, we find no obvious monotonic pattern in adoption of either cap by any outcome measure. Using Wilcoxon rank-sum tests, we fail to reject the equality of the distribution of the number of adoptions of either punitive or noneconomic damage caps across quintiles for any of the outcome measures.

Our second validity check is to test for the presence of pre-existing trends in drug sales leading up to the adoption of either punitive or noneconomic damage caps (or both together). Specifically, we estimate Equation 3 including policy leads of 1, 2 and 3 years prior to the change in policies. If changes in the pharmaceutical market are driving the adoption of tort reform, we would expect to see significant effects in the pre-period of magnitudes similar to our “post-period” coefficients of interest. The results of this test are discussed below in Section E, but we note here that we find no evidence of pre-existing trends.

## **E. Results**

Table 1 presented raw descriptive statistics consistent with our model. Namely, the table shows that prescriptions rise with higher upstream liability for states in which liability is shared across physicians and drug manufacturers. Table 6 presents the analogous regression results, which are consistent with the raw data. As before, the top two rows in panel A report the direct effect of products liability and malpractice liability, respectively, and the third row represents the interaction effect, which is predicted to be positive. The direct effect of products liability is statistically insignificant, while the



direct effect of higher malpractice liability is to lower drug sales by 15-19%. This is consistent with the prediction that global drug manufacturers will not materially respond to changes in one state's laws, even though physicians will.

The interaction effects are positive and significant, as predicted. Panel B aids in the interpretation of these by reporting the predicted change in prescribing behavior that would result from higher products liability, stratified by states with low and high malpractice liability. When malpractice liability is low, higher products liability has no statistically significant effect on prescriptions, consistent with the heterogeneous legal environment model. However, higher products liability boosts drug utilization by over 20% in states where physicians share liability.

In Table 7A and 7B we report the findings stratified according to drugs with and without black box warnings. Table 7A reports the coefficient estimates (analogous to the top part of Table 6), and panels I and II report the estimates for drugs with and without a warning in place, respectively. Since drugs with black box warnings have already disclosed more of their health harms, more of the liability risk is already shifted downstream to doctors. Thus, increasing upstream liability should lead to more muted effects on quantity, because there is less upstream liability to shift onto doctors. This is roughly what we find. In Table 7A we note that the direct effect of products liability is small and insignificant among both sets of drugs. Malpractice liability reduces sales in both cases, but the effect is only significantly offset by increases in producer liability when there is no black box warning in place.

Table 7B shows that in our preferred specification (with state and drug fixed effects), high products liability is always associated with statistically insignificant effects on sales in states with low malpractice liability, as expected. In states with high malpractice liability, higher products liability boosts sales by 24.9% for drugs without a black box warning, but just 12.3% (which is also insignificant) for drugs with a black box warning.

In Table 8 we report the results of our validity check that tested for pre-existing trends in prescriptions prior to the adoption of reforms. Reporting results only for the preferred specification (with state and drug fixed effects), columns I, II and III report the estimated effects for high products liability, high malpractice liability and the interaction, respectively. The top row reports the main effect while the next rows report the 1, 2 and 3 year lags. These results confirm the basic findings and suggest no evidence of pre-existing trends. The lead variables are generally smaller in magnitude and inconsistent in sign compared to the main effects, and none of them is statistically significant. This, combined with the findings reported in Figure 1, support the case for the exogeneity of our policy variables.

### **III. Conclusion**

This paper examined the implications of different tort liability regimes on output in a market defined by vertical production. We show that vertical production spread out across multiple jurisdictions can lead to unintended consequences of higher products liability rules. Conventional wisdom holds that an increase in tort liability on the upstream firm will (weakly) reduce sales of a risky product and improve safety. The theory of vertical production across jurisdictions, however, predicts

that higher upstream liability may actually shield downstream distributors from liability and increase their sales of a risky product.

We test this prediction in the pharmaceutical market, where drug manufacturers face product liability and physicians—who are essentially the downstream distributors of pharmaceutical products—face malpractice liability. The regulation of these two forms of liability differs substantially across jurisdiction. We find that liability on the upstream pharmaceutical company increases the quantity of drugs sold when liability is shared with physicians, but has no effect when downstream physicians are insulated from liability risk. In other words, higher products liability by a single jurisdiction never has its strictly intended consequence, and can even generate perverse unintended consequences.

From a normative perspective, our theory presents a case for harmonized liability rules across jurisdictions. Indeed, it even suggests that individual states can move towards efficiency by aligning their rules with the global average liability rule. This provides some hope for improving the structure of the liability regime. That is, states that focus on the welfare of their own consumers, and that understand the efficiency issues outlined in this study, may have incentives to harmonize with the broader market.

In practice, the political economy of state liability reform encompasses more than just consumer welfare. There may be electoral incentives for individual states to “act tough” on large, upstream firms, or be friendly towards large upstream firms that are housed in their own states. A full analysis of these political economic incentives lies beyond the scope of this paper, but if significant, this would suggest the value of national tort liability rules that naturally harmonize rules across states. Even so, there may continue to be misalignment across countries, since many upstream firms – drug manufacturers included – operate in multiple national jurisdictions. This issue is somewhat mitigated though by the greater ability to price-discriminate across national borders in some cases, including that of the pharmaceutical industry.

Our study suggests the value of investigating how the interaction of multiple independent firms, operating across multiple independent jurisdictions, complicates the effectiveness of tort liability rules. Further research may investigate interactions across goods markets, where multiple risky goods are used to produce a given output. More research is also needed on how these considerations affect the political economy of tort reform at the state and national level. A competitive, complex, and disintegrated economy appears to have important implications for how we study tort reform, and how the economic analysis of tort reform should continue to evolve.

## References

- Avraham, R. (2012). Database of State Tort Law Reforms (DSTLR 4rd). *University of Texas Law and Economics Research Paper*(184).
- Bolton, P., & Dewatripont, M. (2005). *Contract theory*: The MIT Press.
- Chandra, A., Nundy, S., & Seabury, S. A. (2005). The growth of physician medical malpractice payments: evidence from the National Practitioner Data Bank. *Health Aff (Millwood), Suppl Web Exclusives*, W5-240-W245-249.
- Choi, A., & Spier, K. (2010). *Should Consumers be Permitted to Waive Products Liability? Product Safety, Private Contracts, and Adverse Selection*.
- Currie, J., & MacLeod, W. B. (2008). First Do No Harm? Tort Reform and Birth Outcomes. *Quarterly Journal of Economics*, 123(2), 795-830.
- Eisenberg, T., Hannaford-Agor, P. L., Heise, M., LaFountain, N., Munsterman, G. T., Ostrom, B., & Wells, M. T. (2006). Juries, Judges, and Punitive Damages: Empirical Analyses Using the Civil Justice Survey of State Courts 1992, 1996, and 2001 Data. *Journal of Empirical Legal Studies*, 3(2), 263-295.
- Goldman, D. P., Joyce, G. F., Escarce, J. J., Pace, J. E., Solomon, M. D., Laouri, M., . . . Teutsch, S. M. (2004). Pharmacy benefits and the use of drugs by the chronically ill. [Research Support, Non-U.S. Gov't
- Research Support, U.S. Gov't, P.H.S.]. *JAMA*, 291(19), 2344-2350. doi: 10.1001/jama.291.19.2344
- Goldman, D. P., Joyce, G. F., Lawless, G., Crown, W. H., & Willey, V. (2006). Benefit design and specialty drug use. *Health Aff (Millwood)*, 25(5), 1319-1331. doi: 25/5/1319 [pii]
- 10.1377/hlthaff.25.5.1319
- Government Accounting Office. (2000). Major Improvements Are Needed to Enhance Data Bank's Reliability. Washington, DC: GAO.
- Hay, B., & Spier, K. E. (2005). Manufacturer Liability for Harms Caused by Consumers to Others. *American economic review*, 95(5), 1700-1711. doi: doi: 10.1257/000282805775014416
- Helland, E. (2008). *Product Liability and Moral Hazard: Evidence from General Aviation*. Paper presented at the American Law & Economics Association Annual Meetings.
- Helland, E., Klick, J., & Tabarrok, A. (2005). Data watch: Tort-uring the data. *Journal of Economic Perspectives*, 207-220.
- Helland, E., Lakdawalla, D., Malani, A., & Seabury, S. (2010). *Tort Liability and the Market for Prescription Drugs*.
- Helland, E., & Lee, G. (2010). Bargaining in the shadow of the website: disclosure's impact on medical malpractice litigation. *American law and economics review*, 12(2), 462-508.
- Helland, E., & Showalter, M. H. (2009). The Impact of Liability on the Physician Labor Market. *Journal of Law & Economics*, 52, 635-779.
- Hensler, D. R. (2000). *Class action dilemmas: Pursuing public goals for private gain*: Rand Corporation.
- Joyce, G. F., Escarce, J. J., Solomon, M. D., & Goldman, D. P. (2002). Employer drug benefit plans and spending on prescription drugs. *Jama*, 288(14), 1733-1739.
- Kessler, D. P., Sage, W. M., & Becker, D. J. (2005). Impact of malpractice reforms on the supply of physician services. *JAMA: The Journal of the American Medical Association*, 293(21), 2618-2625.
- Klick, J., & Stratmann, T. (2007). Medical Malpractice Reform and Physicians in High-Risk Specialties. *The Journal of Legal Studies*, 36(S2), S121-S142.
- Kornhauser, L. A., & Revesz, R. L. (1989). Sharing Damages among Multiple Tortfeasors. *The Yale Law Journal*, 98(5), 831-884.

- Krauss, M. I. (2002). Product Liability and Game Theory: One More Trip to the Choice-of-Law Well. *BYU L. Rev.*, 759.
- Lakdawalla, D. N., & Yin, W. (Forthcoming). Insurers' Negotiating Leverage and the External Effects of Medicare Part D. *Review of Economics and Statistics*.
- Landes, W. M., & Posner, R. A. (1980). Joint and Multiple Tortfeasors: An Economic Analysis. *The Journal of Legal Studies*, 9(3), 517-555.
- Landes, W. M., & Posner, R. A. (1985). A Positive Economic Analysis of Products Liability. *The Journal of Legal Studies*, 14(3), 535-567. doi: 10.2307/724257
- Legros, P., & Matthews, S. A. (1993). Efficient and Nearly-Efficient Partnerships. *The Review of Economic Studies*, 60(3), 599-611. doi: 10.2307/2298126
- Malani, A., & Reif, J. (2013). *Interpreting Pre-trends as Anticipation: Impact on Estimated Treatment Effects from Tort Reform*.
- Matsa, D. A. (2007). Does malpractice liability keep the doctor away? Evidence from tort reform damage caps. *The Journal of Legal Studies*, 36(S2), S143-S182.
- Mello, M. M., Chandra, A., Gawande, A. A., & Studdert, D. M. (2010). National costs of the medical liability system. *Health Affairs*, 29(9), 1569-1577.
- Miceli, T. J. (1997). *Economics of the Law: torts, contracts, property, litigation*: Oxford University Press, USA.
- Miceli, T. J., & Segerson, K. (1991). Joint liability in torts: Marginal and infra-marginal efficiency. *International Review of Law and Economics*, 11(3), 235-249.
- Oates, W. E., & Schwab, R. M. (1988). Economic competition among jurisdictions: efficiency enhancing or distortion inducing? *Journal of public economics*, 35(3), 333-354.
- Polinsky, A. M., & Rogerson, W. P. (1983). Products Liability, Consumer Misperceptions, and Market Power. *The Bell Journal of Economics*, 14(2), 581-589.
- Prosser, W. L. (1960). The Assault upon the Citadel (Strict Liability to the Consumer). *The Yale Law Journal*, 69(7), 1099-1148. doi: 10.2307/794385
- Schwartz, V. E., & Silverman, C. (2009). Preemption of State Common Law by Federal Agency Action: Striking the Appropriate Balance that Protects Public Safety. *Tul. L. Rev.*, 84, 1203.
- Shepherd, J. (2012). Products Liability and Economic Activity: An Empirical Analysis of Tort Reform's Impact on Businesses, Employment, and Production. *Vanderbilt Law Review*, forthcoming.
- Spence, M. (1977). Consumer misperceptions, product failure and producer liability. *The Review of Economic Studies*, 44(3), 561-572.
- Sturgis, R. W. (1995). *Tort Cost Trends: An International Perspective, 1995*: Tillinghast-Towers Perrin.
- Sykes, A. O. (1983). Economics of Vicarious Liability, The. *Yale LJ*, 93, 1231.
- Towers Watson. (2010). US Tort Cost Trends: 2010 Update Retrieved March 5, 2013, from <http://www.towerswatson.com/assets/pdf/3424/Towers-Watson-Tort-Report-1.pdf>
- Willig, S. H. (1985). Physicians, pharmacists, pharmaceutical manufacturers: Partners in patient care, partners in litigation. *Mercer L. Rev.*, 37, 755.

## Tables

**Table 1. Average quantity of prescription drugs filled per outpatient visit by producer and physician liability regime**

Physician malpractice liability	Products liability for manufacturers		Difference (%)
	Low liability states	High liability states	
All states	1.804	1.845	+2.3%**
Low liability states	1.849	1.753	-5.2%**
High liability states	1.771	1.902	+7.4%**

Notes: Table reports the average number of prescriptions per 1,000 outpatient visits at the drug-state-year level for all 50 states plus DC from 1998-2007. High products liability is defined as states with no punitive damage cap in place; high malpractice liability is defined as states without a noneconomic damage cap in place. A \*\* represents statistical significance at the 1% level or better.

**Table 2. Adoption and repeal of punitive damage caps for products liability cases and noneconomic damage caps in medical malpractice cases by state (1997-2008)**

	Law was adopted or implemented	Law was repealed or no longer in effect
Caps on punitive damages	<i>AK (1998), AL (2000), AR (2003), ID (2004), MO (2005), MS (2003), OH (1997, 2005)</i>	<i>IL (1998), OH (1998)</i>
Caps on non-economic damages	FL (2004), GA(2005), IL(2005), <i>ME (2000), MS (2003), NV (2005), OH (1997), OH (2003), OK (2004), SC (2005), TN (2005), TX (2004)</i>	<i>AK (2006), IL (1998), MI (2004), OH (1998), OR (2000)</i>

Notes: Laws in italics apply to all tort cases; all other laws apply only to medical malpractice cases. These were compiled from McCullough, Campbell, and Lane LLP's Summary of United States Medical Malpractice Law, Ronen Avraham's Data Base of State Tort Law Reforms (1st Edition), the American Tort Reform Association Tort Reform Record (1st Edition), and state statutes.

**Table 3. Summary statistics**

Variable	Mean	Std. Dev.
Prescriptions per 1,000 outpatient visits	1.83	5.95
Fraction in high products liability state	0.59	0.49
Fraction in high malpractice liability state	0.60	0.49
Price per Prescription (\$s)	198	1,028
Fraction generic	0.36	0.48
Fraction with black box warning in place	0.11	0.32
Number of generic competitors in class	11.20	11.47
Number of branded competitors in class	47.57	30.34
Age of drug (years)	13.65	6.55
Number of drugs	1,227	
Observations	510,969	

Notes: Table reports means and standard deviations of selected variables. Observations are at the drug-state-year level. High products liability is defined as states with no punitive damage cap in place; high malpractice liability is defined as states without a noneconomic damage cap in place.

**Table 4. Outcomes from pharmaceutical products liability trials, 1990-2009**

Variable	Mean	Std. Dev.
Had punitive damages (fraction)		
- All cases	0.04	0.19
- Cases with award	0.11	0.31
Punitive damage award (2008 \$ millions)		
- All cases	1.37	14.05
- Cases with any damage award	3.18	21.05
- Cases with a punitive damage award	43.09	66.70
Compensatory award (2008 \$ millions)		
- All cases	5.16	47.94
- Cases with a compensatory damage award	12.64	74.43
Total award (2008 \$ millions)		
- All cases	6.49	50.91
- Cases with any damage award	15.85	78.68
Doctor named as defendant	0.56	0.50
Total number of trials		665

Notes: Data report outcomes of pharmaceutical products liability trials from the LexisNexis Drugs in Litigation (2008 edition) from 1990-2009. Data on award amounts mostly come from jury verdict awards in trials, which could have been adjusted on appeal or in settlement. Settlement amounts were unknown except in rare cases (N=121) and are not included in the award amounts.



**Table 5. Effect of punitive and non-economic damages caps on medical malpractice payments**

	(1)	(2)	(3)	(4)
<i>Dependent variable:</i> Log of payment in medical malpractice cases (2008 \$s)				
<i>A. Regression coefficients</i>				
Direct effect of high products liability	0.010 (0.045)	0.002 (0.032)	0.019 (0.044)	0.010 (0.030)
Direct effect of high malpractice liability	0.129** (0.044)	0.089** (0.024)	0.129** (0.044)	0.088** (0.024)
Interaction effect of high products liability and cases with medication errors			-0.147* (0.062)	-0.146* (0.061)
<i>B. Implied effects</i>				
Effect of high products liability in cases involving alleged medication errors			-13.2%	-13.8% <sup>+</sup>
Fixed effects	State, year, type of alleged malpractice			
State demographic variables	No	Yes	No	Yes
Observations	215,261	215,261	215,261	215,261
R-squared	0.055	0.056	0.055	0.056

Notes: Table reports results of an OLS regression of payment in a malpractice case on the liability environment and case features. Malpractice payment data are from National Practitioner Data Bank and span 1992-2007. Robust standard errors clustered at the state level are reported in parentheses. High products liability is defined as states with no punitive damage cap in place; high malpractice liability is defined as states without a noneconomic damage cap in place. A \*\*, \*, or + indicates statistical significance at the 1%, 5% or 10% level, respectively.

**Table 6. Regression estimates of the effects of products liability (upstream) and medical malpractice liability (downstream) rules on drug quantity**

	(I)	(II)	(III)
<i>Dependent variable: Log number of prescriptions per outpatient visit</i>			
<i>A. Regression coefficients</i>			
Direct effect of high products liability	0.0722 (0.0646)	0.0713 (0.0648)	0.0588 (0.0536)
Direct effect of high malpractice liability	-0.189** (0.0561)	-0.186** (0.0569)	-0.153** (0.0521)
Interaction effect of high products liability and high malpractice liability	0.174** (0.0669)	0.173* (0.0683)	0.147* (0.0620)
<i>B. Implied effects</i>			
Effect of high products liability when malpractice liability is low	+7.2%	+7.1%	+5.9%
Effect of high products liability when malpractice liability is high	+24.7%**	+24.4%**	+20.6%**
Mean of dependent variable (levels)	1.83 prescriptions per 1,000 visits		
Fixed effects	Year, state	Year, state, ther. class	Year, state, drug
Other covariates	Generic status, black box warnings, number of brand competitors, number of generic competitors, drug age, state demographics		

Notes: Table reports the results of regression of the number of prescriptions per outpatient visit against the products liability and malpractice regime of the state. High products liability is defined as states with no punitive damage cap in place; high malpractice liability is defined as states without a noneconomic damage cap in place. Each column reports the results of a different regression based on the fixed effect structure included. Data are at the drug-state-year level. Robust standard errors are reported in parentheses, computed to allow for two-level clustering within states and within therapeutic classes. A \*\*, \*, or + indicates statistical significance at the 1%, 5% or 10% level, respectively.

**Table 7A. Regression coefficient estimates of the effects of state liability regimes on drug quantity stratified by the presence of a black box warning**

	(I)	(II)	(III)
<i>Dependent variable: Log Number of Prescriptions per Outpatient Visit</i>			
<i>A. Drugs with a black box warning in place</i>			
Direct effect of high products liability	0.0760+ (0.039)	0.0742 (0.0576)	0.0701 (0.0711)
Direct effect of high malpractice liability	-0.123** (0.0282)	-0.118* (0.0509)	-0.109+ (0.0622)
Interaction effect of high products liability and high malpractice liability	0.0712+ (0.036)	0.0655 (0.0578)	0.0527 (0.0754)
<i>B. Drugs without a black box warning in place</i>			
Direct effect of high products liability	0.0662 (0.0623)	0.0656 (0.0626)	0.0544 (0.0540)
Direct effect of high malpractice liability	-0.189** (0.0549)	-0.187** (0.0557)	-0.151** (0.0509)
Interaction effect of high products liability and high malpractice liability	0.185** (0.0660)	0.183** (0.0673)	0.155* (0.0618)
Fixed effects	Year, state	Year, state, therapeutic class	Year, state, drug
Other covariates	Generic status, black box warnings, number of brand competitors, number of generic competitors, drug age, state demographics		

Notes: Table reports the results of regression of the log number of prescriptions per outpatient visit against the products liability and malpractice regime of the state. High products liability is defined as states with no punitive damage cap in place; high malpractice liability is defined as states without a noneconomic damage cap in place. Data are at the drug-state-year level. Robust standard errors are reported in parentheses, computed to allow for two-level clustering within states and within therapeutic classes. A \*\*, \*, or + indicates statistical significance at the 1%, 5% or 10% level, respectively.

**Table 7B. Implied effects of state liability regimes on drug quantity stratified by the presence of a black box warning**

	(I)	(II)	(III)
<i>Dependent variable: Log Number of Prescriptions per Outpatient Visit</i>			
<i>A. Drugs with a black box warning in place</i>			
Mean of the dependent variable (levels)	1.78 prescriptions per 1,000 visits		
Effect of high products liability when malpractice liability is low	+7.6% <sup>+</sup>	+7.4%	+7.0%
Effect of high products liability when malpractice liability is high	+14.7%**	+14.0% <sup>+</sup>	+12.3%
<i>B. Drugs without a black box warning in place</i>			
Mean of the dependent variable (levels)	2.20 prescriptions per 1,000 visits		
Effect of high products liability when malpractice liability is low	+6.6%	+6.6%	+5.4%
Effect of high products liability when malpractice liability is high	+22.5%*	+25.1%**	+24.9%**
Fixed effects	Year, state	Year, state, therapeutic class	Year, state, drug
Other covariates	Generic status, black box warnings, number of brand competitors, number of generic competitors, drug age, state demographics		

Notes: Table reports the results of regression of the log number of prescriptions per outpatient visit against the products liability and malpractice regime of the state. High products liability is defined as states with no punitive damage cap in place; high malpractice liability is defined as states without a noneconomic damage cap in place. Data are at the drug-state-year level. A \*\*, \*, or + indicates statistical significance at the 1%, 5% or 10% level, respectively. Variance estimates were computed to allow for two-level clustering within states and within therapeutic classes.

**Table 8. Test for pre-existing trends in drug quantity leading changes in products liability or malpractice regimes**

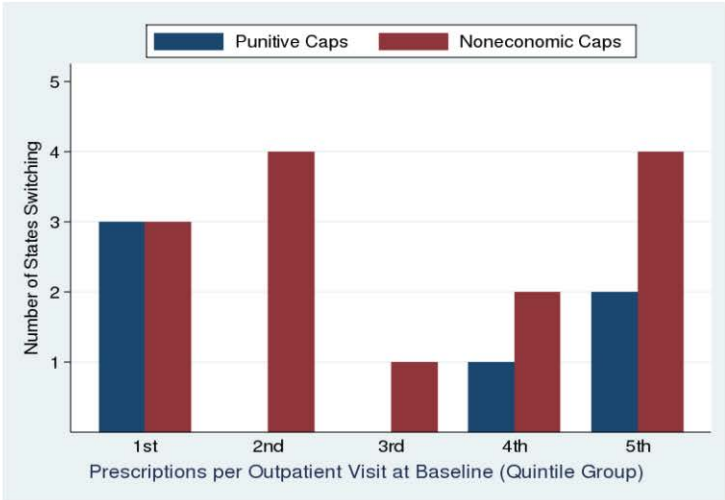
	(I)	(II)	(III)
<i>Dependent variable: Log Number of Prescriptions per Outpatient Visit</i>			
	Direct effect of high products liability	Direct effect of high malpractice liability	Interaction effect of high products liability and high malpractice liability
Direct effect of the policy	0.0820 (0.0954)	-0.180* (0.0726)	0.197* (0.0871)
Policy Leads:			
- 1 year	-0.0594 (0.0916)	0.0829 (0.0957)	-0.121 (0.107)
- 2 years	-0.0371 (0.0795)	0.0716 (0.0842)	-0.0946 (0.0937)
- 3 years	0.0624 (0.162)	-0.0163 (0.0578)	-0.0631 (0.0871)
Fixed effects	Year, state, drug		
Other covariates	Generic status, black box warnings, number of brand competitors, number of generic competitors, drug age, state demographics		

Notes: Table reports the results of regression of the number of prescriptions per outpatient visit against the products liability and malpractice regime of the state. High products liability is defined as states with no punitive damage cap in place; high malpractice liability is defined as states without a noneconomic damage cap in place. Data are at the drug-state-year level. Robust standard errors are reported in parentheses, computed to allow for two-level clustering within states and within therapeutic classes. A \*\*, \*, or + indicates statistical significance at the 1%, 5% or 10% level, respectively.

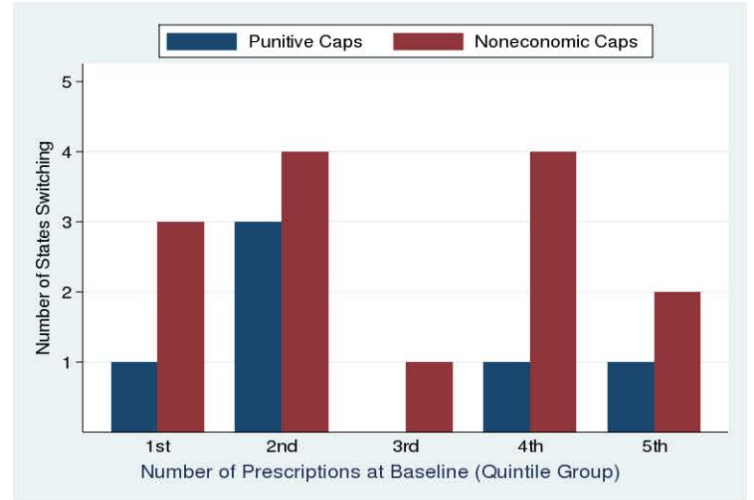
# Figures

Figure 1. Distribution of changes in damages caps by state characteristics.

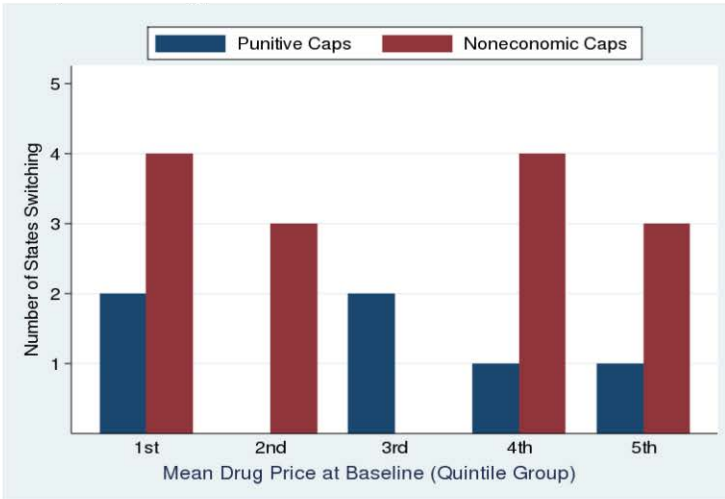
A. By Number of Prescriptions per Outpatient Visit



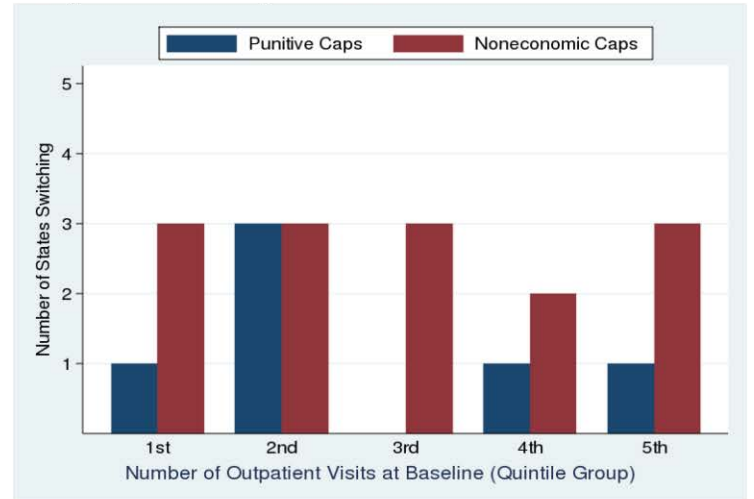
B. By Number of Prescriptions



C. By Mean Drug Price



D. By Number of Outpatient Visits



## Appendix

### A. Proofs

**Proof of Proposition 4.** If condition (a) is met, welfare in jurisdiction  $i$  is

$$W_i(x_i) = V_i(f(x_i)) - [c_x + h]x_i$$

Total across all  $N$  jurisdictions is the sum of the above expression across all jurisdictions  $i$ . An increase in the upstream tort parameter in jurisdiction  $i$  has the following effect on welfare in jurisdiction  $i$ :

$$\frac{\partial W_i(x_i^{**})}{\partial a_i} = [V_i f'(x_i^{**}) - c_x - h] \frac{\partial x_i^{**}}{\partial a_i} \left( \frac{\partial a_i}{\partial t_i} + \frac{\partial a_i}{\partial r} \frac{\partial r^{**}}{\partial t_i} \right)$$

As explained in the text, the term in brackets is negative if  $a_i > \bar{a}$  because that would imply  $\bar{a}h + (1 - a_i) < 1$  and the downstream firm does not internalize the full health costs of the upstream output. For the same reason it is positive if  $a_i < \bar{a}$ . The first term in parentheses ( $\partial a_i / \partial t_i$ ) is positive by assumption. The second term in parentheses is negative: higher upstream liability increases disclosure, which reduces upstream liability. It follows that the effect of a local increase in upstream liability is ambiguous.

Now consider what happens in the limit as  $\sum_{-i} x_j \rightarrow \infty$ . A local increase in upstream liability has no effect on upstream disclosure, i.e.,  $\lim \partial r^{**} / \partial t_i = 0$ , so the term in parentheses becomes positive. Given that  $\partial x^{**} / \partial a_i > 0$ , it follows that the local welfare effect of a local increase in upstream liability is positive if  $a_i < \bar{a}$  and negative otherwise.

The global welfare effect of a local increase in upstream liability is:

$$\sum_j \frac{\partial W_j(x_j^{**})}{\partial t_i} = \frac{\partial W_i(x_i^{**})}{\partial t_i} + \sum_{j \neq i} [V_j f'(x_j^{**}) - c_x - h] \frac{\partial x_j^{**}}{\partial a_i} \left( \frac{\partial a_i}{\partial r} \frac{\partial r^{**}}{\partial t_i} \right)$$

Unlike in the case of design and manufacturing defects, there is no spillover effect on safety in foreign jurisdictions because safety is assumed exogenous. Because the global effect is the local effect (first term) plus the non-local effect (the second term), the impact of a local increase in upstream liability is ambiguous. However, in the limit as  $\sum_{-i} x_j \rightarrow \infty$ , the non-local effect goes to zero because local liability rules cannot affect upstream disclosure. So the global welfare effect converges to the local welfare effect.

### B. Design Defect Liability

The harm to consumers in jurisdiction  $i$  from the hazardous input is assumed to be proportional to its utilization in the final product,  $h(s)x_i$ , where  $s$  is the level of safety investment made by the upstream producer and  $h(s)$  is decreasing and concave ( $h' < 0$  and  $h'' > 0$ ). The cost of safety investment to the upstream firm is  $g(s)$ , where  $g$  is increasing and convex ( $g' > 0$  and  $g'' > 0$ ).

We make two critical assumptions that govern the harm from the hazardous input. First, we assume the upstream firm sells a common product across jurisdictions, so it cannot customize safety investments by jurisdiction. Moreover, we impose a no-arbitrage condition so it must also sell at a common price across jurisdictions.

Second, we assume that demand for the final output does not depend on the harm  $h(s)x_i$ . This is a common assumption in the literature on products liability. In its absence, there may be no need for products liability as consumers can contract directly for the level of safety they desire (Miceli, 1997).<sup>32</sup> This assumption may be reasonable because safety is not observable at the time of contracting or because of ex post haggling costs. It may also be reasonable if consumers have health, life, or property insurance that makes them indifferent to the harm. Each of these assumptions are plausible in the pharmaceutical industry, which we consider in our empirical application.

The total damages awarded by courts in jurisdiction  $i$  are given by  $h(s)x_i$ . This captures the legal restriction that damages cannot generally exceed the losses suffered by consumers.<sup>33</sup> Moreover, we assume that damages are split between the upstream firm and the downstream firm in proportions  $a_i$  and  $(1 - a_i)$ , respectively, where  $a_i \in [0,1]$ . These proportions are a function of each firm's probability of suit and the potential damages to each firm is exposed.

Tort law can, through various mechanisms, influence this allocation. For example damages caps on the upstream firm may make it a less attractive target for suit and reduce the amount of recovery against that firm. For caps on compensatory damages, joint and several liability may also reassign damages in excess of caps to other upstream or downstream defendants. The effect of a specific tort doctrine or reform on the apportionment of damages between firms will depend on how precisely it operates. For now we will simply let the upstream firm's share of damages  $a_i = a(t_i^U, t_i^D)$  depend on tort parameters  $t_i^U$  and  $t_i^D \in [0,1]$ , which describe the upstream and downstream liability exposure, respectively, in jurisdiction  $i$ . We assume upstream share of liability rises in the upstream parameter and falls in the downstream parameter, i.e.,  $a_{i1} > 0$  and  $a_{i2} < 0$ . Moreover, we assume there are values of the tort parameter that ensure either the upstream or the downstream firm bear full liability for damages:  $a(t_i^U, 0) = 1$  and  $a(0, t_i^D) = 0$ .

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<sup>32</sup> There may be a role where consumers demand heterogeneous levels of safety but there is only one (upstream) producer and it can only supply one level of safety. For example, Choi and Spier (2011) consider the case where safety depends on precautions by a single producer and consumers differ in the probability of being harmed by a product. The firm may choose to lower its precaution in order to select for lower risk consumers much as insurance companies may reduce coverage on a given policy in order to adversely select for lower risk beneficiaries. Non-waivable products liability, like an insurance mandate, stops this selection. Note that the sale of multiple products with different levels of safety and price, as in Hay and Spier (2005), can do the same, though it reduces cross subsidization.

<sup>33</sup> An exception is punitive damages, a topic we will take up in the empirical section.



## 1. Homogenous legal environment

First we consider the simple setting in which both the upstream and downstream firms face a homogeneous legal environment, i.e., the upstream firm operates in a number of jurisdictions but a single liability regime governs all those jurisdictions. The main implication of common liability regime is that the upstream firm's share of liability is identical across jurisdictions, i.e.,  $t_i^U = t^U$ ,  $t_i^D = t^D$ , and  $a_i = a \forall i$ .

**Upstream firm.** The hazardous goods producer maximizes profit net of tort liability:

$$\max_s \sum_j x_j (w_x - c_x - g(s) - ah(s))$$

We suppress the arguments of  $a$  here and below where it simplifies the exposition. Because the market is competitive, the hazardous input price is equal to the upstream firm's marginal cost,  $w_x = c_x + g(s) + ah(s)$ . The upstream firm's only choice is over safety  $s$ . The optimal safety investment  $s^*$  balances the cost of safety against lower tort liability:

$$-g'(s^*) = ah'(s^*) \quad (4)$$

Our assumptions about the cost of safety and harms assure an interior solution. It is easily verified that an increase in upstream share of liability will lead to an increase in safety investment because it increases the return to that investment:  $ds^*/da > 0$ . This implies tort parameters that increase the upstream share increase safety investment and vice versa.

**Downstream firm.** The downstream firm in jurisdiction  $i$  maximizes revenue net of input and tort costs:

$$\max_{x_i, z_i} pf(x_i, z_i) - w_x x_i - (1 - a)h(s^*)x_i - c_z z_i,$$

where  $s^*$  is the upstream firm's equilibrium investment in safety.

The ratio of inputs used by the downstream firm is given by

$$\frac{f_{x_i}}{f_{z_i}} = \frac{w_x + (1 - a)h(s^*)}{c_z}$$

To determine how a change in the upstream liability affects downstream behavior, we substitute in the equilibrium price of the hazardous input

$$\frac{f_{x_i}}{f_{z_i}} = \frac{c_x + g(s^*) + h(s^*)}{c_z} \quad (5)$$

As a consequence of having a single liability regime for all jurisdictions, the liability share of the downstream firm,  $1 - a$ , drops out of this expression. The input price passes on the upstream firm's share of tort liability and the allocation of liability has no direct effects and the incentives of both firms are aligned. However, liability share has an indirect effect by shifting the safety investment of the

upstream firm, as summarized in the following proposition. (Proofs are omitted if they are straightforward.)

**Proposition 5.** *Suppose the upstream firm can affect the safety of a product and the downstream firm has chosen interior value of both the hazardous and safe inputs. In a homogenous legal environment, a change in tort parameters that increases upstream liability share  $a$  will cause the downstream firm in each jurisdiction  $i$  to increase use of the hazardous input  $x_i$  and increase downstream output  $y_i$ .*

Because the upstream firm is only partially liable for the harm consumers suffer, it does not internalize the full social marginal cost of the hazardous product ( $c_x + g(s^*) + h(s^*)$ ) and underinvests in safety. A higher share of liability causes it to invest more in safety, reducing the full social marginal cost. The downstream firm, however, does internalize the full social marginal cost of the hazardous product because competitive pricing passes on the upstream firm's costs. Thus the increase in upstream safety investment reduces the downstream firm's marginal cost of using the hazardous input. The downstream firm both uses more of the hazardous input and, seeing a reduction in the average marginal cost of its inputs, also its output.

To identify the socially optimal tort rule, we consider the case of a vertically integrated firm in a competitive market. So long as total tort liability across upstream and downstream production equals the consumer's loss, this integrated firm's behavior will be socially optimal. The integrated firm sets safety to satisfy  $g'(s^*) = -h'(s^*)$  rather than (4). This suggests that, to get first best safety without integration, upstream should bear all liability, i.e.,  $a = 1$ . Since the integrated firm's choice of input ratio matches the non-integrated downstream firm's condition (5), albeit with a different choice of  $s^*$ , full upstream liability will also make the downstream firm behave optimally. This is summarized in the following proposition.

**Proposition 6.** *Under the assumptions of Proposition 1, the first best is achieved by tort rules  $(t^U, t^D)$  that assign all liability to the upstream firm and no liability to the downstream firm, i.e.,  $a(t^U, 0) = 1$ .*

Our finding contrasts sharply with the result in Hay and Spier (2005). An implication of Hay and Spier is that, if the downstream firm can contract on safety, then the assigning all liability downstream makes the downstream firm force the upstream firm to behave optimally through contract. We show that if the downstream firm can only contract on quantity and the downstream firm only affects safety through the quantity of hazardous input it uses, then full upstream liability is optimal.<sup>34</sup> Of course, if the downstream firm also affects consumer harm by its unique investments in safety, then exclusive upstream liability will not achieve the first best. In this case, the first best cannot be achieved unless the downstream firm can contract directly on upstream safety.

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<sup>34</sup> As a practical matter, a policy of exclusive upstream liability can be achieved by unconditionally absolving the downstream firm of any comparative fault.

## 2. Heterogeneous legal environment

We now turn to the more realistic setting in which the upstream firm operates in multiple jurisdictions each with its own tort liability regime. As a result, it is no longer the case that the upstream firm's share of liability is identical across jurisdictions, i.e.,  $t_i^U \neq t^U$  and  $t_i^D \neq t^D$ , so that  $a_i \neq a \forall i$ .

**Upstream firm.** The hazardous goods producer's objective function becomes

$$\max_s \sum_j x_j (w_x - c_x - g(s) - a_j h(s))$$

For simplicity, we assume the market is competitive in the sense that all firms in the market produce identical and perfectly substitutable goods. To highlight the role of producing across jurisdictions, we also assume that upstream firms cannot control where their goods are consumed; therefore, these firms cannot price discriminate across jurisdictions.

Under these assumptions, hazardous input price is proportional to the upstream firm's weighted average liability costs:  $w_x = c_x + g(s) + \bar{a}h(s)$  where  $\bar{a} = \sum_j x_j a_j / \sum_j x_j$  is the sales-weighted average upstream liability across jurisdictions. Since there are constant costs, conditional on a level of safety, the choice of quantity is indeterminate. Instead, the upstream firm's only choice is over safety  $s$ . The optimal safety investment  $s^{**}$  balances the cost of safety against lower tort liability:

$$-g'(s^{**}) = \bar{a}h'(s^{**}) \quad (6)$$

The main implication of the assumption of a heterogeneous legal environment is an increase in the upstream firm's share of liability in one particular jurisdiction  $i$  has smaller positive effects on safety investment than an increase in the firm's share of liability in all jurisdictions, which approximates the effect of an increase in a common liability rule:

$$\frac{ds^{**}}{da_i} = \frac{x_i}{\sum_j x_j} \left( \sum_j \frac{ds^{**}}{da_j} \right) > 0 \quad (7)$$

In the limit, as the output share of jurisdiction  $i$  shrinks to zero, an increase in the upstream firm's share of liability in jurisdiction  $i$  will have no effect on upstream investment in safety. Formally, if we define  $X_{-i} = \sum_{j \neq i} x_j$  be the total output in jurisdictions other than  $i$ , then  $\lim_{X_{-i} \rightarrow \infty} \partial s^{**} / \partial a_i = 0$ .<sup>35</sup>

**Downstream firm.** The downstream firm's objective is the same as before, except that we replace the common rule  $a$  with the jurisdiction specific rule  $a_i$ :

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<sup>35</sup> Comparative statics yields

$$\frac{\partial s^{**}}{\partial a_i} = \frac{x_i h'(s^{**})}{-Xg''(s^{**}) - \sum_j x_j h''(s^{**})} > 0$$

Because the denominator – the second order condition for  $s$  – goes to  $-\infty$  as  $X_{-i} \rightarrow \infty$ ,  $\partial s^{**} / \partial a_i$  goes to 0 as  $X_{-i} \rightarrow \infty$ .

$$\max_{x_i, z_i} pf(x_i, z_i) - w_x x_i - (1 - a_i)h(s^{**})x_i - c_z z_i$$

The ratio of inputs used by the downstream firm is given by

$$\frac{f_{x_i}}{f_{z_i}} = \frac{w_x + (1 - a_i)h(s^{**})}{c_z}$$

If we substitute in the equilibrium price of the hazardous input, we see that, because the upstream firm only passes on the average level of liability, the liability share of the downstream firm does not drop out of the numerator.

$$\frac{f_{x_i}}{f_{z_i}} = \frac{c_x + g(s^{**}) + \{\bar{a} + (1 - a_i)\}h(s^{**})}{c_z} \quad (8)$$

From this we can deduce that, if the upstream liability share in that jurisdiction is above average, the downstream firm in jurisdiction  $i$  consumes too much of the upstream output from a social welfare perspective. Because the upstream firm sets safety as if it is facing average liability in each jurisdiction, the downstream firm's choice of hazardous input would maximize social welfare conditional on the upstream firm's behavior so long as it faced the full cost of health harms. If  $a_i < \bar{a}$ , however,  $\{\bar{a} + (1 - a_i)\}h(s^{**}) < h(s^{**})$ .

The direct effect of increasing upstream liability in one particular jurisdiction  $i$  is to lower the liability cost faced by the downstream firm:

$$\left[ \frac{\partial \bar{a}}{\partial a_i} - 1 \right] h(s^{**}) < 0$$

The indirect effect of increasing  $a_i$  is to increase the safety investment of the upstream firm,

$$\{\bar{a} + (1 - a_i)\}h'(s^{**}) \frac{\partial s^{**}}{\partial a_i}$$

This sign of this term depends on whether  $a_i$  is above or below average, though equation (7) shows the effect vanishes as the output share of jurisdiction  $i$  falls to zero. The implication for trade is presented in the following proposition.

**Proposition 7.** *Suppose the upstream firm can affect the safety of a product and the downstream firm has chosen interior value of both the hazardous and safe inputs. In a heterogeneous legal environment, an increase in upstream liability share  $a_i$  will cause the downstream firm to increase use of the hazardous input  $x_i$  and increase downstream output  $y_i$  either if  $a_i$  is above  $\bar{a}$  or as the output share of jurisdiction  $i$  falls to zero.*

In contrast with the case of a homogenous legal environment, the first best cannot be achieved. The first best requires that all jurisdictions have identical liability rules that place all liability on the upstream firm:  $a_i = a = 1 \forall i$ . However, this violates the assumption of a heterogeneous legal

environment. More significantly, an increase in upstream liability in jurisdiction  $i$  alone may have negative implications for welfare in a heterogeneous legal environment!

**Proposition 8.** *Under the assumptions of Proposition 3, if  $a_i > \bar{a}$ , as the upstream firm's sales  $X_{-i}$  in jurisdictions other than  $i$  increases, an increase in upstream liability  $a_i$  will reduce welfare in jurisdiction  $i$  and may even reduce welfare in all jurisdictions. If  $a_i < \bar{a}$ , an increase in upstream liability  $a_i$  will increase welfare in all jurisdictions.*

**Proof.** *To simplify, we ignore the safe input and assume  $y_i = f(x_i)$ . For the proof we will need the following facts.*

Fact 1. *Comparative statics on the downstream firm's behavior reveals*

$$\frac{\partial x_i^{**}}{\partial a_i} = -\frac{1}{pf''(x_i^{**})} \left[ \left\{ 1 - \frac{x_i}{X} \right\} h(s^{**}) - \{ \bar{a} + (1 - a_i) \} h'(s^{**}) \right] \frac{\partial s^{**}}{\partial a_i} > 0$$

*This converges to  $-h(s^{**})/pf''(x_i^{**}) > 0$  as  $X_{-i} \rightarrow \infty$ .*

Fact 2. *Comparative statics also reveals the effect of increasing  $a_j$  on  $x_i$ :*

$$\frac{\partial x_i^{**}}{\partial a_j} = -\frac{1}{pf''(x_i^{**})} \left[ -\frac{x_j}{X} h(s^{**}) - \{ \bar{a} + (1 - a_i) \} h'(s^{**}) \right] \frac{\partial s^{**}}{\partial a_j}$$

*This is ambiguous: the first term in the bracket is negative and the second is positive. However, as  $X_{-i} \rightarrow \infty$ , this becomes 0 because  $x_j/X \rightarrow 0$  and  $\partial s^{**}/\partial a_j \rightarrow 0$ .*

*Now we turn to welfare. Let  $v_i(q)$  be in the inverse demand function in jurisdiction  $i$ . Let  $V_i(q)$  be the integrated inverse demand function, i.e., the consumer surplus under appropriate assumptions, in that jurisdiction. Welfare in jurisdiction  $i$  is*

$$W_i(x_i, s) = V_i(f(x_i)) - [c_x + g(s) + h(s)]x_i$$

*Global welfare is  $\sum_j W_j$ .*

*Taking the derivative of welfare in jurisdiction  $i$  at the private optimum yields*

$$\frac{\partial W_i(x_i^{**}, s^{**})}{\partial a_i} = [V_i f'(x_i^{**}) - c_x - g(s^{**}) - h(s^{**})] \frac{\partial x_i^{**}}{\partial a_i} + [-g'(s^{**}) - h'(s^{**})] x_i^{**} \frac{\partial s^{**}}{\partial a_i}$$

*The second term is positive because the upstream firm underinvests in safety and higher upstream liability increases upstream safety investment. The sign of the first term depends on the relationship between  $a_i$  and  $\bar{a}$ . Consider two cases.*

Case 1: *If  $a_i < \bar{a}$ , the downstream faces more than the full health costs of upstream output, so it under-consumes  $x_i$ , implying the first term is positive. Thus, for  $a_i < \bar{a}$ , an increase in  $a_i$  improves welfare in jurisdiction  $i$ .*

*Case 2.* If  $a_i \geq \bar{a}$ , an increase in  $a_i$  will cause the downstream firm to fail to bear the full health cost of the upstream output, implying they over-consume that output. Thus, the first term is negative. The overall effect for jurisdictions in which  $a_i \geq \bar{a}$  is ambiguous. However, as  $X_{-i} \rightarrow \infty$ , the second term drops out, leaving just the first, negative term.

Now consider welfare across all jurisdictions, which is the sum  $\Sigma_i W_i$ . An increase in upstream liability in jurisdiction  $i$  has the following effect:

$$\Sigma_j \frac{\partial W_j(x_j^{**}, s^{**})}{\partial a_i} = \Sigma_j [V_j f'(x_j^{**}) - c_x - g(s^{**}) - h(s^{**})] \frac{\partial x_j^{**}}{\partial a_i} + [-g'(s^{**}) - h'(s^{**})] \frac{\partial s^{**}}{\partial a_i} X$$

This is ambiguous. Though the second term is positive, we have shown that the first is ambiguous even in jurisdiction  $i$ . As  $X_{-i} \rightarrow \infty$ , the expression above becomes

$$[V_i f'(x_i^{**}) - c_x - g(s^{**}) - h(s^{**})] \lim_{X \rightarrow \infty} \frac{\partial x_i^{**}}{\partial a_i} + \lim_{X \rightarrow \infty} [-g'(s^{**}) - h'(s^{**})] \frac{\partial s^{**}}{\partial a_i} X$$

The first term simplifies because  $\partial x_j^{**} / \partial a_i \rightarrow 0$  for all  $j \neq i$ . However, the second term may be positive if  $\partial s^{**} / \partial a_i$  does not converge to 0 faster than  $X_{-i}$  goes off to  $\infty$ . When  $a_i < \bar{a}$ , the effect of a local increase in upstream liability increases global welfare. When  $a_i \geq \bar{a}$ , the effect is ambiguous. However, given that the global effect differs from the jurisdiction  $i$  effect in the limit because the second term is multiplied by  $X$  rather than merely  $x_i$ , the global effect of locally increasing upstream liability is much more positive than the local effect of that increase.

Consider a jurisdiction where, because  $a_i$  is above average, the downstream firm already over-consumes  $x_i$ . At some point the upstream firm operates in enough jurisdictions that, an increase in liability in jurisdiction  $i$  increases the use of the hazardous input in jurisdiction  $i$  more than it reduces the per-unit harm of that input. Total welfare in jurisdiction  $i$  falls. This is offset to some extent by the spillover effect that jurisdiction  $i$ 's legal rule has on the per-unit safety of the hazardous input sold in other jurisdictions. Thus higher upstream liability is not destined to decrease global welfare as the firm operates in more jurisdictions, though it may. In jurisdictions where  $a_i$  is below average, the downstream firm underproduces. Thus the salutary effect of an increase in  $a_i$  on downstream input improves welfare

### C. Proofs for Model with Upstream Monopolist

In this section, we extend and generalize our main results to an environment in which the upstream firm is a monopolist.

#### 1. Failure to Warn

As before we begin our analysis by considering the case where there is a homogeneous legal environment so that caps are identical across jurisdictions, i.e.,  $t_i^U = t^U$  and  $t_i^D = t^D \forall$ .

**Upstream firm.** In this context, the hazardous good producer solves the following:

$$\max_{r, w_x} \sum_i x_i(r, w_x)(w_x - c_x - a(t^U, t^D, r)h)$$

Input demand falls in the degree of safety disclosures, so that  $\frac{\partial x_i}{\partial r} < 0$ , and it is downward-sloping, so that  $\frac{\partial x_i}{\partial w_x} < 0$ . Finally, note that the cross-partial between  $r$  and  $w_x$  is zero, under the simplifying assumption that  $f_z$  is constant for the downstream firm. All these results flow from the optimal input demand of the downstream firm. (As before,  $a_U > 0$  and  $a_D < 0$ .)

This problem has the following first-order conditions:

$$\sum_i \frac{\partial x_i}{\partial w_x} (w_x - c_x - ah) + \sum_i x_i = 0$$

$$\sum_i \frac{\partial x_i}{\partial r} (w_x - c_x - ah) + \sum_i x_i (-a_r h) = 0$$

When  $T_U$  rises, the FOC for  $r$  rises, holding  $w_x$  fixed, indicating that  $r$  must go up. The price effect is offsetting, however, as the monopolist raises her price in response to the higher level of  $T_U$ . In the heterogeneous jurisdiction case, however, this effect is negligible. Therefore, an increase in the upstream tort parameter causes the upstream firm to disclose more risks:  $\partial r / \partial t^U > 0$ .

**Downstream firm.** The downstream firm in jurisdiction  $i$  solves the following problem:

$$\max_{x_i, z_i} p_i f(x_i, z_i) - (w_x + (1 - a(t^U, t^D, r^*)h)x_i - c_z z_i)$$

where  $r^*$  is the upstream firm's equilibrium level of disclosure.

$$p f_x = w_x + (1 - a)h$$

$$p f_z = c_z$$

$$w_x = c_x + ah - \frac{\sum_i x_i}{\sum_i \frac{\partial x_i}{\partial w_x}}$$

After plugging in the upstream firm's prices, the ratio of inputs used by the downstream firm is given by

$$\frac{f_{x_i}}{f_{z_i}} = \frac{c_x + h - \frac{\sum_i x_i}{\sum_i \frac{\partial x_i}{\partial w_x}}}{c_z} \quad (9)$$

Just as in the design or manufacturing defect liability case, a change in upstream liability due to disclosure is perfectly offset by a reduction in downstream liability due to that disclosure. Although the downstream firm only observes the marginal harm  $rh$  that the upstream firm discloses, the upstream price passes on the costs associated with non-disclosed harms. Disclosure drops out of the marginal

condition for input choice and the downstream firm faces the full marginal harm  $h$  from use of the hazardous input. Note that we are abstracting from the inefficiencies associated with monopoly pricing, which are unrelated to the tort regime per se.

An important feature of the design or manufacturing defect case, however, is that a change in tort exposure affects input choice despite the fact that liability share  $a$  drops out the marginal condition. The reason is that tort exposure separately affects the harm from the hazardous input through the upstream firm's choice of safety investment:  $h'(s) < 0$ . In the failure to warn case, by contrast, the upstream firm cannot change the harm from the hazardous input and so tort law has no effect on downstream input choice. The following proposition summarizes these findings.

**Proposition A-3.** *Suppose the upstream firm cannot affect the safety of a product and the downstream firm has chosen interior values for both the hazardous and safe inputs. In a homogenous legal environment, a change in tort parameters that increases upstream liability share  $a$  will have no effect on the downstream firm's use of the hazardous input  $x_i$  or its output  $y_i$ .*

A remarkable byproduct of this result is that, in the context of vertical production, higher or lower tort liability and thus higher or lower disclosure has no effect on welfare!

**Proposition A-4.** *Under the assumptions of Proposition 5, the allocation of liability  $a$  across firms and tort rules  $(t^U, t^D)$  have no effect on welfare. The market is always at the first-best level of welfare.*

This result rests critically on certain assumptions we have made. First and foremost, we examine a homogenous legal environment. In the next subsection, we will show that, in a heterogeneous legal environment, upstream liability is not perfectly passed on through price and thus changes in tort rules affect downstream input choice. Second, we have chosen a parameterization of upstream and downstream liability where the consumer is fully compensated for his or her injuries. A less demanding sufficient condition is that a dollar decrease in one firm's liability increases the other firm's liability by a dollar, even if the consumer is not fully compensated.

## 2. Design Defects

**Upstream firm.** The upstream firm maximizes

$$\max_{w_x, s} \sum_i x_i(w_x)(w_x - c_x - g(s) - ah(s))$$

We suppress the arguments of  $a$  here and below where it simplifies the exposition.

$$w = c + g + ah - \frac{x}{x_w}$$

$$-g'(s^*) = ah'(s^*)$$

Our assumptions about the cost of safety and harms assure an interior solution for the safety investment problem. It is easily verified that an increase in upstream share of liability will lead to an increase in safety investment because it increases the return to that investment:  $ds^*/da > 0$ . This



implies tort parameters that increase the upstream share increase safety investment and vice versa. Note in particular that the monopolist's safety investment decisionmaking is identical to the competitive upstream firm's, because safety does not affect the downstream firm's willingness to pay.

**Downstream firm.** The downstream firm in jurisdiction  $i$  maximizes revenue net of input and tort costs:

$$\max_{x_i, z_i} pf(x_i, z_i) - w_x x_i - (1 - a)h(s^*)x_i - c_z z_i,$$

where  $s^*$  is the upstream firm's equilibrium investment in safety. The ratio of inputs used by the downstream firm is given by

$$\frac{f_{x_i}}{f_{z_i}} = \frac{w_x + (1 - a)h(s^*)}{c_z}$$

To determine how a change in the upstream liability affects downstream behavior, we substitute in the equilibrium price of the hazardous input

$$\frac{f_{x_i}}{f_{z_i}} = \frac{c_x + g(s^*) + h(s^*) - \frac{x}{x_w}}{c_z} \quad (10)$$

As a consequence of having a single liability regime for all jurisdictions, the liability share of the downstream firm,  $1 - a$ , drops out of this expression. The input price passes on the upstream firm's share of tort liability and the allocation of liability has no direct effects and the incentives of both firms are aligned. However, liability share has an indirect effect by shifting the safety investment of the upstream firm, as summarized in the following proposition. (Proofs are omitted if they are straightforward.)

**Proposition A-1.** *Suppose the upstream firm can affect the safety of a product and the downstream firm has chosen interior value of both the hazardous and safe inputs. In a homogenous legal environment, a change in tort parameters that increases upstream liability share  $a$  will cause the downstream firm in each jurisdiction  $i$  to increase use of the hazardous input  $x_i$  and increase downstream output  $y_i$ .*

Because the upstream firm is only partially liable for the harm consumers suffer, it does not internalize the full social marginal cost of the hazardous product ( $c_x + g(s^*) + h(s^*)$ ) and underinvests in safety. A higher share of liability causes it to invest more in safety, reducing the full social marginal cost. The downstream firm, however, does internalize the full social marginal cost of the hazardous product because competitive pricing passes on the upstream firm's costs. Thus the increase in upstream safety investment reduces the downstream firm's marginal cost of using the hazardous input. The downstream firm both uses more of the hazardous input and, seeing a reduction in the average marginal cost of its inputs, also its output.

To identify the socially optimal tort rule, we consider the case of a vertically integrated firm. So long as total tort liability across upstream and downstream production equals the consumer's loss, the

integrated firm's behavior will be socially optimal. The integrated firm sets safety to satisfy  $g'(s^*) = -h'(s^*)$  rather than (4). This suggests that, to get first best safety without integration, upstream should bear all liability, i.e.,  $a = 1$ . Since the integrated firm's choice of input ratio matches the non-integrated downstream firm's condition (5), albeit with a different choice of  $s^*$ , full upstream liability will also make the downstream firm behave optimally. This is summarized in the following proposition.

**Proposition A-2.** *Under the assumptions of Proposition 1, the first best safety investment is achieved by tort rules  $(t^U, t^D)$  that assign all liability to the upstream firm and no liability to the downstream firm, i.e.,  $a(t^U, 0) = 1$ .*

Our finding contrasts sharply with the result in Hay and Spier (2005). An implication of Hay and Spier is that, if the downstream firm can contract on safety, then the assigning all liability downstream makes the downstream firm force the upstream firm to behave optimally through contract. We show that if the downstream firm can only contract on quantity and the downstream firm only affects safety through the quantity of hazardous input it uses, then full upstream liability is optimal.<sup>36</sup> Of course, if the downstream firm also affects consumer harm by its unique investments in safety, then exclusive upstream liability will not achieve the first best. In this case, the first best cannot be achieved unless the downstream firm can contract directly on upstream safety.

The heterogeneous case produces identical results to that under competition, with additional notation.

#### **D. Description of claims data**

The data include enrollment files, medical and pharmacy claims and health plan benefits, and span 1997 to 2007. Enrollment records allow us to track who is eligible for services as well as basic demographics (age, gender, three-digit zip code of residence, and relationship to sponsoring employee). Pharmacy claims in the data include all outpatient pharmaceutical purchases. Each claim includes the type of drug, drug name, National Drug Code (NDC), dosage, days supplied, place of purchase (retail or mail-order), payments by patients and health plans, type of drug dispensed (generic, multi-source brand, single-source brand), type of pharmacy (retail, mail-order), and type (new/refill). The number of health plans contributing data varies each year, with more than 40 plans contributing in the last two years. Thus, there are 421 plan-years of data in the existing data set. About 44 percent of these plan-years ( $n=187$ ) cover retiree benefits, so there is substantial representation of older Americans in the data. Plans also vary in the length of time they appear in the data. Currently, there are 28 plans with five or more years of data.

The data are also representative of all major plan types (health maintenance organizations, HMOs; preferred provider organizations, PPOs; point-of-service, POS, plans; and fee-for-service, FFS, plans) with members in all 50 states. In 2005, approximately 41 percent of the sample was enrolled in

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<sup>36</sup> As a practical matter, a policy of exclusive upstream liability can be achieved by unconditionally absolving the downstream firm of any comparative fault.

HMOs; 25 percent, in PPOs; 24 percent, in POS plans; and the remainder in FFS plans. Geographically, 43 percent of enrollees resided in the South, 32 percent in the North Central region, 14 percent in the West, and 11 percent in the Northeast.

In the claims data, pharmacy claims are coded by NDC, a unique product identifier created by the FDA. However, the same “drug” could be assigned multiple NDCs according to different strength, dose or differences in the packaging or labeling of the product. For example, a search of the drug Lipitor on the FDA website reveals more than 75 different NDC codes.<sup>37</sup> We aggregate these claims to the drug level according to the active ingredient (also referred to as the molecule name or “generic name”). We linked the data by NDC code to the 2007 Redbook and aggregated all claims according to the active ingredient name by the state, year gender and age-category level. Of course, even after adjusting for the national representativeness of the sample, some of the variation in quantity across states and years could be driven by variation in the size of the population or the utilization of medical services. Thus, we also computed the number of outpatient visits—the encounter most likely to result in a prescription—for each state, year gender and age category in Ingenix. Using the weights constructed by comparing Ingenix enrollment to the CPS population, we constructed weighted averages of prescriptions per outpatient visit at the drug, state and year level.

#### **E. Testing effects on price and the number of adverse events**

Throughout the discussion of the empirical application, we have asserted that drug firms set their prices nationally. Our primary justification for this is market structure: prices are negotiated between drug companies and a small handful of pharmacy benefit managers that represent insurance companies in numerous states (Lakdawalla and Yin, 2011). We also assert that exposure to varying exposure to liability rules should not impact the price of drugs. Appendix Table 1 tests of this assumption by regressing price on liability rules at the national level.

To conduct this test, we identify the effect of liability by comparing a drug that becomes more heavily exposed to liability rules over time (due to the particular geographic distribution of its sales) to one that does not become more heavily exposed (because of its different distribution of sales). To be concrete, suppose that  $Q_{igt}$  is the number of prescriptions of drug  $g$  per 1,000 outpatient visits in state  $i$  at time  $t$ , and  $L_{it}$  is an indicator for whether state  $i$  has a relevant damages cap  $L_{it}$  at time  $t$ . Our measure of liability exposure for drug  $g$  at time  $t$  is:

$$\alpha_{gt} = \frac{\sum_i Q_{igt}(1 - L_{it})}{\sum_i Q_{it}}$$

In short, a drug has a higher score on our liability index the higher the fraction of its sales that are in states without tort reform.

We find drugs with more sales in states with higher products liability are not associated with significantly different prices. Note that the table format is slightly different from those in the text,

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<sup>37</sup> See <http://www.accessdata.fda.gov/scripts/cder/ndc/proprietaryname.cfm>, accessed on December 1, 2013.

because as we aggregate exposure to liability rules at the national level we have to construct average exposure to each of the four groups and compare each to the reference group of low products and low malpractice liability. Our empirical results suggest no significant effect of exposure to liability rules on price.

Note that this approach is limited because it assumes the liability shares are exogenous. We know from Table 6 that liability rules do affect state-level quantity, which casts doubt on this assumption. However, to the extent that these effects are small compared to other factors that drive geographic variation in drug utilization (most notably, geographic variation in health), these findings confirm the assertion that price is unrelated to liability rules.

In Appendix Table 2 we report a similar test on the number of adverse drug events as reported to the FDA in the Adverse Event Reporting System AERS. The AERS data do not provide geographic information, so we were unable to test for adverse events according to state-level variation in sales. We did test for the effect of liability rules on the overall number of adverse events at the national level using the liability exposure measure described above. We tested separately for effects on all events, serious events and fatalities. We find that there is an increase in the number of adverse events associated with exposure to high products liability and high malpractice liability, and that the effect is of approximately the same magnitude as the effect of liability on the quantity of prescriptions. This is suggestive that firms are not able to modify the safety profile of their drugs to offset the potential exposure to liability, though it is subject to the same criticisms as discussed above.

**Appendix Table 1. Regression estimates of the impact of liability regimes on the price of prescription drugs**

	(I)	(II)
<i>Dependent variable: Log Total Payments per Prescription</i>		
Effect of exposure to high products liability	-0.0440 (0.0448)	
Effect of exposure to high malpractice liability	-0.0346 (0.0563)	
<i>Reference group: Low products liability and high malpractice liability</i>		0.00
Effect of exposure to low products liability and high malpractice liability		-0.0647 (0.0633)
Effect of exposure to high products liability and low malpractice liability		-0.0363 (0.0525)
Effect of exposure to high products liability and high malpractice liability		0.127 (0.0919)
Fixed Effects	Year, Drug	
Other Covariates	Generic status, black box warnings, number of brand competitors, number of generic competitors, drug age	

Notes: Table reports the results of regression of the log total payments per prescription against the products liability and malpractice regime of the state. High products liability is defined as states with no punitive damage cap in place; high malpractice liability is defined as states without a noneconomic damage cap in place. Liability regime is measured as the share of filled prescriptions in states with high liability. Data are at the drug-year level. Robust standard errors are reported in parentheses, computed to allow for clustering within therapeutic classes. A \*\*, \*, or + indicates statistical significance at the 1%, 5% or 10% level, respectively.

**Appendix Table 2. Regression estimates of the impact of liability regimes on the number of adverse drug events**

	(I)	(II)	(III)
	<i>Dependent variable:</i>		
	All adverse events	Serious adverse events	Fatal events
<i>Reference group: Low products liability and high malpractice liability</i>	0.00	0.00	0.00
Effect of exposure to low products liability and high malpractice liability	-0.0394 (0.0768)	-0.0851 (0.0700)	-0.127** (0.0474)
Effect of exposure to high products liability and low malpractice liability	0.0402 (0.0514)	-0.00643 (0.0458)	-0.0333 (0.0391)
Effect of exposure to high products liability and high malpractice liability	0.179* (0.0852)	0.0769 (0.0689)	-0.0440 (0.0468)
Fixed Effects	Year, Drug		
Other Covariates	Generic status, black box warnings, number of brand competitors, number of generic competitors, drug age		

Notes: Table reports the results of regression of the log total payments per prescription against the products liability and malpractice regime of the state. High products liability is defined as states with no punitive damage cap in place; high malpractice liability is defined as states without a noneconomic damage cap in place. Liability regime is measured as the share of filled prescriptions in states with high liability. Data are at the drug-year level. Robust standard errors are reported in parentheses, computed to allow for clustering within therapeutic classes. A \*\*, \*, or + indicates statistical significance at the 1%, 5% or 10% level, respectively.