Reasonableness*

Scott Baker
Washington University in St. Louis
bakerscott@wustl.edu

Giri Parameswaran
Haverford College
gparames@haverford.edu

April 9, 2024

Abstract

This paper investigates what makes behavior reasonable. Two actors exert effort towards a goal. The planner knows each actor's cost of effort. The actors know their own costs, but not their counter-party's. We find that the planner will not base incentives on the actors' cost of care (information that is free and accurate). Instead, the planner identifies a common standard of "reasonableness" for many agents to follow to foster coordination and avoid waste. Meanwhile, the planner forgives the least able and holds them to a lower standard customized to their costs, while never upping the standard for the most able.

Key Words: Reasonable Person, Asymmetric Information, Coordination, Task-specialization.
JEL Codes: D7, K1, K4, L2

*We thank Gary Biglaiser, Bernie Black, Dan Epps, Claude Fluet, Ezra Friedman, Simon Grant, Louis Kaplow, Pauline Kim, Lewis Kornhauser, Claudio Mezzetti, Rohan Pitchford, Steven Shavell, Kathy Spier, and Abe Wickelgren for comments. We also thank workshop participants at the following institutions: Australian National University; Columbia Law School; Harvard Law School; Haverford College; Macquarie University; Melbourne University; Monash University; Northwestern University School of Law, Queensland University; Sydney University; Toulouse School of Economics; Washington University in St. Louis; and participants at the 2022 Society for the Advancement of Economics Theory annual meeting, and the 2022 Law and Economic Theory Conference.

In many everyday interactions—driving, dating, working, selling —'reasonableness' defines acceptable behavior. Reasonable behavior is permissible; unreasonable behavior is not. The 'reasonable' person standard is used to decide legal cases from torts, contracts, and property, to employment discrimination and ERIS, to the required disclosures under securities laws. But what exactly does reasonable even mean, and why do we require it? Our model explains why "being reasonable" is such a pervasive cultural and legal idea. It also explains why, sometimes, excusing or forgiving some individuals for "being unreasonable" leads to a superior allocation of resources.

In the model, two agents take efforts that contribute towards a common goal. Effort decisions are complements: the effectiveness of an agent's effort depends on her counter-party's. As a result, a mismatch of effort can generate inefficiencies: circumstances where an actor exerts effort that is wasted due to a lack of effort by her counter-party. Each party knows her own cost of effort but, importantly, is ignorant of the counter-party's. A planner wishes to provide incentives, constrained by the fact that the agents know very little about each other.

The planner has tools she can use to provide incentives. Before deploying those, she must figure out the choices she wants the agents to make. Specifically, the planner must decide whether to induce agents with different effort costs to make different effort choices or, alternatively, induce agents with different costs to take the same effort. The first choice results in a personalized or customized effort schedule, where what the planner demands of the agent reflects that agent's specific talents. The second choice results in an objective effort schedule or standard, where the planner treats differently situated agents (those with different effort costs) as identical. For this objective standard, the planner ignores what she knows about the actor's cost in setting incentives.

Our simple set-up arises whenever a decision must be made whether to treat differently situated agents on a team the same or different. Take a manager overseeing a supply chain that is non-integrated and has several links. Production depends on the effort of each supplier in the chain. The suppliers are located around the globe and know little about each other. Should the manager customize or objectify each supplier's performance standard? Likewise, in setting performance standards (e.g., for tenure) and codes of conduct, universities and businesses must decide whether to hold different workers to different standards or to some common standard associated with a typical worker.

Although objective standards govern behavior in many settings, our primary motivation is rooted in law. A recurring character in the common law is the "reasonable" person—a disembodied hypothetical construct intended to establish the proper measure of behavior. If a party's behavior is as at least good as the objective 'reasonable person's', then it bears no liability. The reasonable person, in turn, is the 'average person,' the figurative "man on the Clapham Omnibus"[1] whose traits are those commonly found in the community. Indeed, as Holmes (1881) remarks: "the standards of law are standards of general application. . . . [They require] a certain average of conduct, a sacrifice of individual peculiarities going beyond a certain point."

Well-known examples of the reasonable person standard in the law include:

- Torts: To prevail in a tort case, the plaintiff must prove that the defendant failed to use reasonable care to prevent the accident (Dobbs, Hayden, & Bublick, 2015, p.213). Courts define reasonable care as the "care, attention or skill a reasonable person would use under similar circumstances" (MSBNA Standing Committee on Pattern Jury Instructions, 2009).

- Property: To prevail in a private nuisance claim, the plaintiff must show that the defendant's actions "substantially and unreasonably interferes with [the] use and enjoyment of [their] property."[2]

- Contracts: An offer for sale arises when a reasonable person standing in the shoes of the offeree would conclude that his assent, and only his assent, is needed to create an enforceable agreement.

Reliance on the reasonable person standard entails costs. Under the standard, less able individuals must take precautions whose cost to them is greater than the benefits of those precautions to others, and gifted persons can forgo taking precautions that are personally cheap for them, but expensive for the average person. The cost-benefit calculation of the reasonable person is a fiction that rarely matches the cost-benefit calculation of a real person. By relying on objective standards, the law seems to ignore information that would be relevant to any cost-benefit analysis. This is a puzzle.

More puzzling is that, after ignoring costs for most agents, the law then finely tailors the standard of conduct for some individuals according to their cost — and it does so asymmetrically. It lowers the standard and forgives those with a high cost of compliance (for example, children) while seldom heightening the standard for those with a low cost of compliance.

[1] *McQuire v Western Morning News* [1903] 2 K.B. 100 at 109 per Collins MR.
[2] DelVecchio v. Collins, 178 A.D.3d 1336.

So, why use objective standards? For one, the court might find measuring an individual's aptitude costly. The law and economics literature has explored this reason in detail (Holmes, 1881; Posner, 2014; Shavell, 1987). We place this concern to one side by assuming, as noted above, that the planner or court knows (1) each actor's cost of effort and (2) the effort they undertook. As such, the planner could, if they wanted to, perfectly personalize standards of conduct to an individual's costs/abilities and customize compensation schemes accordingly. The first result shows that the planner would not want to do this.

We find that the planner or court will couple objective standards for the most able agents with forgiveness for the least able agents. In so doing, the planner trades off the benefits of coordination against the costly failure to customize performance standards. On the one hand, by holding actors to the same conduct or benchmark, the planner ensures coordination of efforts, which, due to complementarity, mitigates waste. On the other hand, objective standards sacrifice the benefits of linking the effort required to its cost.

The planner induces pooling among enough of the more able actors to ensure that gains from the coordinated effort are maximized for the 'average' ability of the actor in the pool — the definition of reasonableness under the law. The pooling region always contains the most able actors, those with the lowest effort cost. In this region, the standard is objective, meaning actors are held to the same standard despite heterogeneity in their costs of effort. On the other hand, the region of excuses contains the least able, the ones with the highest cost of effort, and is fully customized to the actor's cost.

Consider an example. To prevent a traffic accident, both the pedestrian and the motorist should exercise care. Suppose that, given the ways accidents happen, the probability of an accident is primarily determined by the less careful party. For example, a motorist driving recklessly significantly increases the likelihood of an accident and the severity of harm, even if the pedestrian exercises due care, and vice versa. Given this complementarity, whatever accident prevention efforts the motorist (say) takes above and beyond what the pedestrian does are wasted. The motorist pays for those extra efforts, but they do not reduce the probability of an accident. In this admittedly extreme example, the need to coordinate effort is striking. The best thing is for the pedestrian and the motorist to take the same amount of care.

Asymmetric information (between the parties, who are strangers) makes coordination difficult. Suppose the motorist has a low cost of care. If the law induces him to take lots of effort—a decision consistent with his low cost—there is a good chance that the effort will be wasted. Requiring the motorist to use a high degree of care only makes sense if the pedestrian can be expected to mirror that choice. But the pedestrian will only take great care if she also has a low cost of care, which is far from certain. In utilizing the reasonable person standard, courts improve the chance of coordination by having the low-cost motorist chisel on his care. Society wants the low-cost motorist to ignore his talent for harm prevention; to instead do what the "typical" motorist would do. Likewise, society is unforgiving to some (but not all) higher-cost pedestrians. It forces these pedestrians to bump up their care to some "average" level, matching the choice of the motorist who, no matter his cost, is also doing what the "average" person would do. Notably, through an objective standard, the law tosses away seemingly relevant information, namely each individual's cost of care.

Viewed from the low-cost motorist's perspective, the presence of pedestrians with higher costs of care infects the pool of counter-parties. The more pedestrians with high costs in the pool, the more (mis)-coordination becomes an issue and the greater the distortion in the care decision of the low-cost motorist. Pedestrians with high costs of taking care are like having lemons in the used car market. A rule for allocating accident liability that, in effect, compresses effort decisions towards the mean solves this problem: it provides sufficient certainty to low-cost agents that their efforts in taking care will not be wasted. With that said, compression to the mean necessarily entails a sacrifice in the fine-tuning of the law to the particular abilities of the actors. This results in a mismatch between what parties could do to prevent accidents and what the law demands. Stated differently, the law is both over and under-inclusive. It demands too little care from some actors and too much care from others, as a price paid to induce coordination and avoid waste.

In the used car market, it is unnecessary to rid the market of all lemons to resolve the adverse selection problem — as long as the number of lemons remaining is not too large. The same insight applies to our setting. Coordinating enough agents on the same 'objective' care level may sufficiently mitigate adverse selection to enable the planner to tailor the standard of care for the remaining (highest cost) agents. Specifically, the planner can hold these high-cost agents to a more forgiving standard, one that more closely reflects their costs.

The model makes several predictions, many of which are reflected in judge-made law. First, the analysis suggests that "reasonableness" should govern behavior when the effectiveness of precautions by one party turns on the precautions taken by someone else. By contrast, absent a need to coordinate, courts should be willing to hold highly skilled agents to a higher standard.

The common law reflects this pattern. For instance, courts deploy different standards of care when a leasing relationship is transient—an innkeeper-guest relationship—rather than permanent—a landlord-tenant relationship; more specifically, the law imposes a heightened obligation on an innkeeper to prevent the harm associated with third-party criminal activity. Rationalizing this distinction, the Virginia Supreme Court[3] wrote:

> Unlike a landlord, an innkeeper is in direct and continued control of the property and usually maintains a presence on the property personally or through agents. Thus, 'while a lessee may be expected to do many things for his own protection,' an innkeeper's guest is not as well situated to do so.

When one party controls the environment, there is no need to coordinate efforts at crime prevention. In a more permanent occupancy, both the tenant and the landlord can make safety improvements, and the failure of either measure exposes the property to crime. Given this complementarity, the law does not want to encourage landlords to invest heavily in safety unless tenants do as well.[4] Notably, the potential for waste is less pressing in temporary housing such as hotels. In those settings, the occupant lacks the authority to invest in securing the property.[5]

A similar dynamic arises in trust law, wherein trustees possessing greater skill at investing are held to a higher standard, commensurate with their skill level. Since trustees typically manage trusts independently of the beneficiary, the scope for coordination, and corresponding role for reasonableness to align incentives, are absent.

If the reasonable person standard were solely a response to the difficulty arising from the judicial measurement of costs (the classic argument), we would not observe these legal distinctions based on control. Our model, by contrast, accounts for these common law doctrines as responses to the presence or absence of a need to coordinate activity.

Second, as noted, the model highlights that objective standards should often go hand-in-hand with lenient standards of conduct for the less able. The common law embeds this

[3] *Taboada v. Daly Seven, Inc.* 641 S.E.2d 68 (2007).

[4] Romero v. Twin Parks Se. Houses, Inc., 70 A.D.3d 484, 484 (2010)("Landlords have a common-law duty to take minimal precautions to protect tenants from foreseeable harm, including a third party's foreseeable criminal conduct....However, an injured tenant may recover damages 'only on a showing that the landlord's **negligent** conduct was a proximate cause of the injury.")(emphasis added).

[5] On related lines, Merrill (1985) writes: "The law imposed a heightened standard of care on keepers of inns, the only multiple dwelling structures known at common law. This special duty was justifiable because the innkeeper could not expect guests to make necessary repairs due to the temporary nature of the guests' stay at the inn."

principle. For a child to be liable for a tort, he must fail to exercise the care associated with a child of "the same age, intelligence, and experience under like circumstances."[6] Likewise, a person with a physical disability must conform his conduct to "that of a reasonable man under a like disability" (American Law Institute, 1965, §283(C)).

Third, we show that the decision of whether an agent should be held to a rigorous or forgiving standard (given her cost) can be decoupled from the decision about what those standards should be. In legal practice, judges decide the appropriate standard of conduct and whether an excuse is available; jurors or trial judges then apply the standard in specific cases. Unlike prior models, this real-world distinction arises endogenously in the model. Specifically, the threshold that separates the types of agents who are pooled from those who are excused depends only on the distribution of costs and is independent of the technology that translates effort into the common goal. Thus, the law could, as it in fact does, allow the appellate judge to decide the "extent of the pool" question, while the jury assesses whether the defendant met his obligation in light of the evidence about the returns from effort in that specific case.

Furthermore, because of this decoupling, even if the harm technology operates differently in different circumstances, the set of agents who can avail themselves of excuses will be unchanged. Thus, while what the law demands of adults will differ depending on the context (e.g., more care should be exercised when driving in rainy conditions), the fact that all adults are held to the same standard will not. Likewise, what the law demands of children will always be more forgiving than what it demands of adults. But what exactly the more forgiving standard is will depend on the context in which the accident occurs.

Pivoting from the law, the decoupling result informs debates about who should set performance standards (e.g. at tenure review) at universities and businesses. A university might set a presumption of non-discrimination in tenure standards coupled with a list of excuses for relaxation of the standard (parental obligations, COVID relief, etc.). After articulating these policies, the university can then delegate decisions about whether the standard is met to the departments, meaning these standards can vary dramatically across departments in line with local discipline-specific expectations and practices.

Fourth, beyond establishing a new explanation for reasonableness standards, the model provides insights into what determines the breadth of the standard: how many actors are pooled and how many are excused. As effort complementarity increases, the width of the pooling region increases, and the width of the excuse region narrows. At the same time, the effort in-

[6] Ardinger v. Hummell, 982 P.2d 727 (Alaska 1999).

duced under the objective benchmark falls. In other words, with increased complementarity, more agents are subject to a less onerous objective standard.

In fact, under certain conditions, the planner—despite knowing just how differently talented each agent is—will hold all actors to the same, objective reasonable person standard. Moreover, this standard will correspond to the first-best standard of care for someone with the average effort cost in the population. The result aligns with the common law tradition, where the "[reasonably prudent man] does not mean an ideal or perfect man, but an ordinary member of the community. He is usually spoken of as an ordinarily reasonable, careful, and prudent man"(Terry, 1915, p.47).

Finally, beyond explaining the role of the reasonable standard, this analysis offers a justification for its continued use. Given technological advances that make learning about individualized characteristics cheaper and easier, some legal scholars advocate that liability should become more and more personalized (Ben-Shahar & Porat, 2016). Our analysis shows that even if courts or regulators could use big data to learn everyone's personalized costs, the state could not harness this information to create better incentives. And thus it isn't worthwhile to gather the information in the first place. The issue is that individuals often must interact with one another before they know much about each other. And the promise of big data is unlikely to plug this knowledge gap in fleeting encounters between strangers.

After a brief discussion of related literature, the paper unfolds as follows. Section 1 develops a model of accident law. Section 2 articulates the first-best benchmarks, assuming the planner and the actors are all fully informed. Section 3 studies efficiency in a second-best environment, where each agent's standard of conduct only depends on their cost and not their counterparty's. Section 4 shows that the common law rules found in judicial decisions can induce agents to make the second-best choices. Section 5 considers some extensions and limitations of the model, and Section 6 concludes.

Related Literature

Our work relates and builds off different approaches to understanding reasonableness. Philosophers argue that the reasonable person standard embodies positive virtues such as mutual respect, reciprocity, and fair terms of cooperation (Keating, 1995). (Zipursky, 2015, p. 1243) aptly summarizes this position:

> Reasonableness requires a sense of fitting one's demands alongside the multiple demands of others, which one accommodates to a certain extent

Our model fleshes out one meaning of "reciprocity" in the law. It explains when (and why) the law should hold certain actors to the unwavering standard of conduct and when it should be more forgiving.

Landes and Posner (1987) define as 'reasonable' actions that are consistent with cost-benefit analysis. Of course, as noted above, different people have different costs of accident prevention, suggesting that the law should be finely tailored. Landes and Posner (1987) and Shavell (1987) show that the one-size-fits-all reasonable person standard arises when the courts cannot observe cost differences among individuals. Shavell (1987) offers another account, suggesting that the reasonable person standard operates as a tax, encouraging individuals with a high cost of compliance to shift away from the activity that might cause harm.

Unlike the prior law and economics literature, we assume the court knows each actor's cost of exercising care. Instead, frictions arise because the parties do not *themselves* know the cost of others with whom they interact, and thus cannot predict the actions of their counter-parties.[7]

We are unaware of any economic models exploring the coordination/customization trade-offs associated with the reasonable person standard. That said, our message is that it can be efficient for the planner to ignore information that is perfectly accurate and free. That message appears elsewhere in the economics literature. For example, in the principal-agent setting, Cremer (1995) and Sappington (1986) demonstrate that a principal can benefit from remaining ignorant about the agent's characteristics. Ignorance enables the principal to avoid renegotiating in a way that damages the agent's ex-ante incentives. Similarly, Taylor and Yildirim (2011) demonstrate that by committing to blind review a principal can create better incentives for the agent to produce good projects. Likewise, ignorance about the past behavior of an opponent can create a strategic advantage, dulling the consequences of the first-mover advantage (Schelling, 1980, p.161).

The insight here differs from these works. In this model, the planner perfectly observes effort. As a result, if the planner could condition each agent's incentives on their own cost of effort *and* their counter-parties, the planner could achieve the first-best. Nonetheless, because the agents are ignorant about each other, the planner prefers not to base incentives

[7]Garoupa and Dari-Mattiacci (2007) examine this same information problem in a model where care decisions are perfect substitutes. They show that a court will find it taxing to create appropriate incentives using a negligence standard, and advocate for fines instead. We characterize the optimal legal rule for any degree of complementarity between care decisions. Our focus is the reasonable person standard rather than the choice of the vehicle for controlling conduct.

on information the agents do, in fact, know. In other words, if the planner cannot use all the information available to it, she is better off using none of it.

On this point, we find an analog in the Bernheim and Whinston (1998) model of strategic ambiguity. There, the parties refuse to explicitly condition behavior on verifiable information about, say, the manager if they cannot also explicitly condition on the worker's behavior. The refusal to condition enhances the freedom of the manager and, in so doing, facilitates more effective punishment for deviations by the worker from the implicit arrangement. This model has nothing to do with the credibility of punishment. Instead, the planner refuses to use free and accurate information because of a need to foster coordination and avoid waste among asymmetrically informed agents.

1 A Model of Accidents

The model consists of a large number of motorists (m) and pedestrians (p). The interactions between a motorist and a pedestrian can lead to an accident. Each motorist and each pedestrian must decide how much care to take in preventing the accident. The court or planner decides on a liability schedule. Facing that schedule, the motorist selects a care level of $x_m \geq 0$, and the pedestrian selects a care level of $x_p \geq 0$.

Motorists and pedestrians differ in the cost of exerting care. Let c_i be the unit cost of care for each player $i \in \{m, p\}$. The cost of care parameter, the player's type, is drawn from a continuous distribution $G_i(c)$, that admits a strictly positive density $g_i(c)$, with support on $[\underline{c}_i, \overline{c}_i]$, where $\underline{c}_i > 0$. For technical reasons, we require that $G_i(c)$ satisfy the decreasing generalized reverse hazard rate property (see Che, Dessein, & Kartik, 2013; Faravelli, Man, & Walsh, 2015). Formally, we require that $c\frac{g_i(c)}{G_i(c)}$ be weakly decreasing over its domain.[8] In settings where the agents draw costs from the same distribution (i.e. $G_m(c) = G_p(c) = G(c)$), we can replace this assumption with the requirement that the distribution be unimodal.

The court observes each c_i perfectly. Thus, the court can, if it so chooses, successfully use a fully customized standard for both actors. While unrealistic, this assumption allows us to put aside the most common explanation for objective standards: namely, that courts find them cheap to apply. (Holmes, 1881; Landes & Posner, 1987; Shavell, 1987).

[8] Many common distributions with positive support, including the uniform, triangular, chi-square, gamma, log-normal, exponential, Pareto, and Beta (provided $\alpha, \beta > 1$) distributions, satisfy this assumption. A sufficient condition for this property to hold is that G be 'sufficiently' log-concave. Formally, let $r_i(c) = -c\frac{d^2 lnG_i(c)/dc^2}{dlnG_i(c)/dc}$ be the analog of the coefficient of relative risk aversion. It suffices that $r_i(c) \geq 1$.

The efforts of the pedestrian and the motorist combine to determine the likelihood and size of harm. We wish to examine how the interdependence of effort choices influences what the court deems permissible behavior. Denote the expected harm from the accident as $\Pi(a)$, where a is a measure of the central tendency of the two agent's effort choices. As is standard in models of accidents, assume that the function Π is twice continuously differentiable, strictly decreasing and strictly convex ($\Pi'(a) < 0$ and $\Pi''(a) > 0$). Additionally, assume that Π satisfies the Inada conditions.

The measure of the central tendency of care between the agents, a, is constructed to reflect complementarity between care decisions. For tractability, we adopt the *ordered weighted average* (OWA) technology as the central tendency measure:[9]

$$a(x_p, x_m; \lambda) = \lambda \max\{x_m, x_p\} + (1 - \lambda) \min\{x_m, x_p\}$$

where $\lambda \in [0, 0.5]$. The OWA technology returns a weighted average of the two care levels, guaranteed to lie between the minimum and maximum care taken. Since $\lambda \leq 0.5$, the technology assigns more weight to the agent taking less care, reflecting the intuition that the more reckless actor drives the likelihood of harm.

This technology enables a parsimonious articulation of the degree of substitutability between the agents' care decisions. The parameter $\lambda \in [0, 0.5]$ captures the degree of substitutability of care between agents. When $\lambda = 0.5$, the technology simplifies to the arithmetic mean, $a(x_m, x_p) = \frac{1}{2}x_m + \frac{1}{2}x_p$, and care levels can be perfectly substituted for each other. When $\lambda = 0$, the technology reduces to the Leontief technology, $a(x_m, x_p) = \min\{x_m, x_p\}$, and substitution is not possible. Any degree of substitutability between these extremes corresponds to a value of $\lambda \in (0, 0.5)$.[10]

We use the OWA technology to capture substitutability instead of the more familiar CES technology.[11] In our setting, the CES technology has an unappealing feature: when the

[9]Though it is not commonly used, the OWA technology has antecedents in the economics literature, most famously in the Hurwicz criterion (Hurwicz, 1951), which provides a method to balance optimism and pessimism when agents make decisions under uncertainty. Most commonly, it has been used to study decision-making under conditions of ambiguity (see Xiong & Liu, 2014; Yager, 2002, 2004). But the OWA technology has been applied in a wider range of contexts, including the modeling and measurement of inflation (León-Castro, Espinoza-Audelo, Merigó, Gil-Lafuente, & Yager, 2020), asset valuation (Doña, la Red, & Peláez, 2009), exchange rate forecasting (León-Castro, Avilés-Ochoa, & Gil Lafuente, 2016), risk analysis (Blanco-Mesa, León-Castro, & Merigó, 2018), and government accountability (Avilés-Ochoa, León-Castro, Perez-Arellano, & Merigó, 2018), amongst others.

[10]We could extend the framework to include $\lambda > .5$. Results will mirror the case of perfect substitutes.

[11]Recall the CES technology is given by: $b(x_m, x_p; \rho) = \left(\frac{1}{2}x_m^\rho + \frac{1}{2}x_p^\rho\right)^{\frac{1}{\rho}}$, where $\frac{1}{1-\rho}$ is elasticity of substitution. Like the OWA technology, the CES technology includes perfect substitutes ($\rho = 1$) and perfect

motorist and pedestrian choose similar care levels, the CES function is locally approximated by a perfect substitutes technology regardless of the value of ρ.[12] We conjecture that complementarity in care motivates the planner's need and desire to coordinate behavior between heterogeneous agents. Yet the CES technology does not meaningfully capture complementarity when agents match their care decisions. And that makes it a poor fit for this problem.

We now proceed in two steps. Section 3 asks what the planner (or efficiency-minded court) would like the agents to do, thus establishing efficiency benchmarks. Section 4 shows how liability for an accident can be allocated so that each agent finds it in their best interest to make the choices identified by the planner.

2 Benchmarks

The planner's (or an efficiency-minded court's) objective is to minimize the sum of accident costs and prevention costs.[13] We begin with two benchmarks.

2.A. Unilateral Problem

Consider the optimal level of care in an analogous model with only a single actor. The average care, a, is the care taken by the actor. The optimal level of care x_u satisfies:

$$\min_{x_u} \Pi(x_u) + cx_u.$$

The efficient care level is $x_u = [\Pi']^{-1}(-c) = z(c)$. The function z maps the cost of care into its optimal level for the unilateral actor and will play a starring role in what follows. It is easily shown that $z'(c) < 0$, so that as the cost of care rises, the efficient unilateral care level falls. The level of care, $z(c)$, is efficient, and it is what the court strives to implement when designing the legal rules.

complements ($\rho \to -\infty$) as special cases. Section 5.A. discusses the implications of assuming this alternative "smoother" technology. With some qualifications, the results are robust to this alternative specification.

[12]To see this, note that for all ρ, a first-order Taylor approximation of the CES aggregator centered at (x_m^0, x_p^0) with $x_m^0 = x_p^0$ gives: $b(x_m, x_p; \rho) \approx \frac{1}{2}x_m + \frac{1}{2}x_p = b(x_m, x_p; 1)$.

[13]In *United States v. Carroll Towing Co.*, 159 F.2d 169 (2d. Cir. 1947), Judge Learned Hand set forth this understanding of the objectives of accident law. See also Brown (1973); Calabresi and Hirschoff (1971); Posner (2014); Shavell (1987).

2.B. Bilateral Problem with Full Information

Now take two actors. In the full information benchmark, the actors' costs are observable to everyone — the court and the actors themselves — and so the planner (or court) can condition each agent's care level on *both* agents' costs. As in the unilateral benchmark, the first-best care decisions minimize the social loss associated with accidents and accident prevention:

$$\min_{x_m, x_p} \Pi(a(x_m, x_p; \lambda)) + c_m x_m + c_p x_p$$

Let $\mathbf{1}[\cdot]$ denote the indicator function. The first-best care schedules are characterized by:

Proposition 1. *Let* $\overline{\lambda}(c_m, c_p) = \frac{\min\{c_m, c_p\}}{c_m + c_p} \leq \frac{1}{2}$*. If the care technology is characterized by:*

- *(Imperfect) Substitutes (i.e. if* $\lambda > \overline{\lambda}(c_m, c_p)$*), then:*

$$x_i^{1st}(c_m, c_p) = \frac{1}{\lambda} z\left(\frac{c_i}{\lambda}\right) \cdot \mathbf{1}[c_i < c_{-i}]$$

- *(Imperfect) Complements (i.e. if* $\lambda \leq \overline{\lambda}(c_m, c_p)$*), then:*

$$x_m^{1st}(c_m, c_p) = x_p^{1st}(c_m, c_p) = z(c_m + c_p)$$

The first-best care decisions exist in one of two regimes. If the degree of complementarity is high (i.e., λ is small), then the planner wants to coordinate both agents to take the same level of care. Moreover, since both agents must pay the cost of providing this care, the optimal care level coincides with the one that would be optimal for a unilateral agent facing unit cost $c_m + c_p$.

If, instead, the degree of complementarity is low (i.e., λ is relatively high), then the planner will assign the full burden of taking care to the 'least cost avoider', while allowing the higher cost agent to sit idle.[14] This result tracks the insight from the early literature in law and economics (Calabresi & Hirschoff, 1971; Demsetz, 1972) that courts should decide on liability by hunting for the least cost avoider, a call that holds sway among some the justices of the United States Supreme Court.[15]

[14] The 'bang-bang' nature of this result, with the least cost abater being wholly responsible for care, is an artifact of the piece-wise linear average care technology. As we note in Appendix B, with a more convex technology, the first-best care levels in this region would be more 'continuous'.

[15] *Air & Liquid Sys. Corp. v. DeVries*, 139 S. Ct. 986, 997 (2019)(Gorsuch, J., dissenting)("The manufacturer of a product is in the best position to understand and warn users about its risks; in the language of law and economics, those who make products are generally the least-cost avoiders of their risks.").

Implementing the first-best is difficult, if not impossible, since it requires that each actor know not only her own cost, but that of her counter-party. As noted by Garoupa and Dari-Mattiacci (2007), to induce first-best care decisions, it is not sufficient for the court to uncover each actor's cost of care through litigation. Rather, at the time of the interaction, the actors must know the cost of care for everyone else they might be involved in an accident with. This information is, in reality, unavailable.

With these benchmarks in mind, we next examine what the standards of conduct should be, given that the actors know a lot about themselves but little about others with whom they interact.

3 Second-Best Analysis

In the first-best, the planner or court was able to condition the care level of each agent on the costs of both agents. In the second-best, we constrain the planner to choose care levels for each agent only based on that agent's cost and without regard to the counter-party's cost, a cost the agent does not know.

To motivate and illustrate the main ideas of the second-best, we start with a baseline case. Assume the care decisions are perfect complements and the actor's costs are drawn from the same distribution. As noted, the court observes each actor's costs, but the actors do not observe the cost realization of their counter-party.

With this information structure, the court can set standards as a function of each actor's individual costs, but not as a function of the "pair" of costs associated with both parties to the accident. Should it do so? Seemingly yes.

The planner (or court) chooses care schedules $x_m(c)$ and $x_p(c)$ to solve:

$$W = \min_{x_p(c), x_m(c)} \iint \{\Pi(\min\{x_p(c_p), x_m(c_m)\}) + c_p x_p(c_p) + c_m x_m(c_m)\} g(c_p) g(c_m) dc_p dc_m$$

Straightforwardly, the second-best care schedule $x_i(c_i)$ is continuous and weakly decreasing in c_i. If the schedules were strictly decreasing, they *separate* each agent's types according to their cost of care; the care schedules perfectly tag the agent's effort to the cost of its provision. Yet tailoring care to how much it costs to provide is only part of the court's calculus. The court also wants to facilitate coordination to avoid wasted effort.

We will now show that coordination concerns ensure that the court holds actors whose costs lie an interval $[\underline{c}, \hat{c}]$ to the same objective standard. In other words, the planner sets the standard without referencing these actors' costs. The argument proceeds by first positing a perfectly separating schedule and then showing that this schedule cannot be strictly decreasing as required in any separating solution.

In the separating schedule, the care level for each type must satisfy the first-order condition. Notice that a marginal increase in the pedestrian's care only reduces accidents when she takes less care than the motorist. Otherwise, the additional care is wasted. But, because the pedestrian does not know the motorist's cost of care (or equivalently, the care level the motorist with that unit cost has been encouraged to take by the court), the pedestrian's care can only be fixed according to the distribution of costs. The pedestrian therefore must treat the motorist's care as a random variable. Of course, the counter-party's cost of effort may be learned *ex-post* at trial. Yet the court cannot condition behavior on something the agents themselves do not know *ex-ante*.

Focusing on the pedestrian, we have the following first order condition:

$$\Pi'(x_p)\,\Pr[x_m(c_m) > x_p(c_p)] + c_p = 0$$

where the probability is taken with respect to the distribution over c_m.

Next, we exploit the symmetry in our setup (and in particular the assumption of identical cost distributions) to assert that the motorist and pedestrian must have the same care schedules, i.e. $x_p(c) = x_m(c) = x(c)$ for all c. The probability term then reduces to:

$$\Pr[x_m(c_m) > x_p(c_p)] = \Pr(c_m < c_p) = G(c_p)$$

Because the schedule must decrease in c, the pedestrian's care is lower when they have a higher cost than the motorist. And that happens with probability $G(c_p)$.

Accordingly, the first-order condition becomes:

$$\begin{aligned} c_p + G(c_p)\Pi'(x_p) &= 0 \\ x(c_p) &= [\Pi']^{-1}\left(-\frac{c_p}{G(c_p)}\right) = z\left(\frac{c_p}{G(c_p)}\right) \end{aligned} \tag{1}$$

The ratio $\frac{c_p}{G(c_p)}$ represents the pedestrian's *effective* cost of care. It is the cost of increasing the average care level by 1 unit *in expectation*, given that marginal effort is sometimes wasted.

The effective cost of care increases in the actor's unit cost and decreases as the agent's effort becomes more likely to be pivotal and not wasted. It is this cost, the court uses to determine the care level it wants the agent to take.

Consider now the lowest cost type. Suppose this type takes a hefty dose of care, consistent with the meager cost of providing it. Further, suppose every other type takes care tailored to their cost. In that setting, the care of the lowest cost type is wasted for sure.

As we approach the lowest cost type, we have $\lim_{c\to\underline{c}} \frac{c}{G(c)} = \infty$ (since $\underline{c} > 0$). With an infinite effective cost of care, it follows from the Inada conditions that $x(\underline{c}) = 0$. Yet, in a separating decreasing schedule, agents with costs a little above $\underline{c}$ must do strictly less than zero, and this cannot be.

To explore the logic another way, notice that since $z' < 0$, the second-best schedule will be decreasing whenever $\frac{c}{G(c)}$ is increasing. But, given that $\underline{c} > 0$, it must be that $\frac{c}{G(c)}$ is decreasing for c close to $\underline{c}$. In fact, combined with the monotone generalized reverse hazard rate assumption, we can show that $\frac{c}{G(c)}$ is first decreasing and then increasing.

Thus, we have shown both that $x(c)$ cannot be strictly decreasing when c is low and that it may be strictly decreasing when c is large. This explains an asymmetry: excuses or relaxed standards exist for high-cost actors, but low-cost actors are not subject to heightened standards. As we have explained, the reason is that adverse selection has its strongest bite when applied to agents taking higher care levels. Furthermore, tailoring is only optimal when c is large enough.

This baseline case assumes perfect complementarity of care, creating a big push to coordinate conduct. Yet, our result is not simply that complementarity demands perfect coordination. We find that the court has a counter-veiling incentive to forgive high-cost agents and have them put forth less effort than others. Indeed, if the court can induce sufficient matching among low-cost agents, relief to high-cost agents becomes worthwhile.

Having established that the solution must involve some pooling, the next steps involve: (a) determining the breadth of the pool region and (b) the care level for the pool members.

Suppose the court pools agents with costs $[\underline{c}, \tilde{c}]$ for some arbitrary $\tilde{c} > \underline{c}$. The care level that minimizes the social loss within the pool is the solution to:

$$\min_x \Pi(x)G(\tilde{c})^2 + 2x \int_{\underline{c}}^{\tilde{c}} cg(c)dc$$

The first term is the probability the pedestrian and motorist both draw costs in the pooling region and thus are pivotal to determining harm. The second term is the cost born by agents in the pool (whether their care is pivotal or not). Taking the first order condition gives:

$$\tilde{x} = z\left(\frac{2E[c \mid c < \tilde{c}]}{G(\tilde{c})}\right) \tag{2}$$

Let us interpret this. As expressed in proposition 1, with perfect complements, the first-best care level turns on the sum of the cost realizations of the pedestrian and motorists. In the second-best, conduct is determined by the sum of the expected *effective* costs among those in the region adjusted for the probability of waste. (Since the agents are drawn from the same cost distribution, the sum of expected costs is simply twice the conditional expectation.) The second-best care level is simply the first-best standard in one focal circumstance: when the motorist realizes the average cost and she is paired with a pedestrian who realizes the average cost (within the pool). Thus, the pooling standard is, in fact, a reasonable person standard — it treats all agents as if they were the average person.

We are left to characterize the boundary (which we denote by $\hat{c}$) between the pooling and separating regions of the second-best schedule. Intuitively, the planner will create incentives so that there is a threshold agent indifferent between the objective standard and the optimal tailored (i.e. excused) standard. Let $\hat{x}$ denote the pooling care level implied by pooling region $[\underline{c}, \hat{c}]$. The threshold type's care level must satisfy:

$$\hat{x} = z\left(\frac{\hat{c}}{G(\hat{c}}\right) = z\left(\frac{2E[c \mid c < \hat{c}]}{G(\hat{c})}\right)$$

$$\hat{c} = 2E[c \mid c < \hat{c}] \tag{3}$$

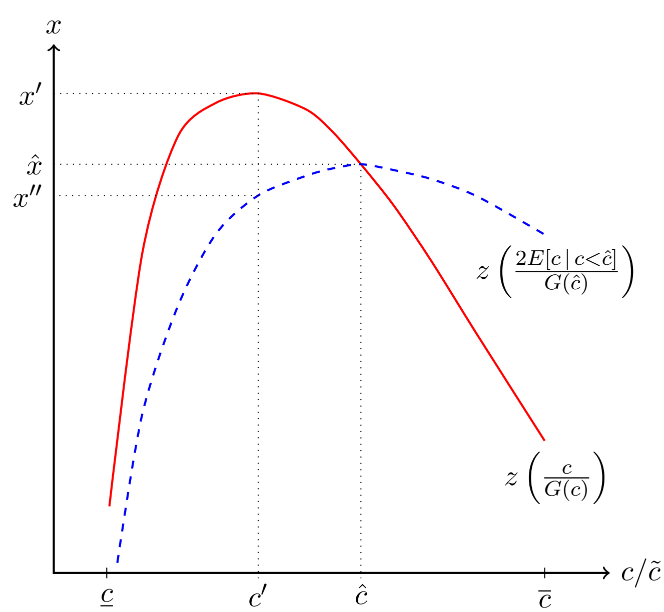
Figure 1 illustrates the mechanics behind the result. The horizontal axis reflects the cost parameter. The solid (red) curve represents the optimal separating level of care, where the standard of care is tailored to the agent's cost. This is given by equation (1) above. Notice that this function assigns strictly more care to higher cost agents for $c < c'$, which we know cannot be in any solution. As a result, the planner must at least pool agents in the region $[\underline{c}, c']$. However, an even broader pool may be optimal.

The dashed (blue) curve is the optimal care for the pooling types when the interval $[\underline{c}, \tilde{c}]$ forms the pool (where the horizontal axis now measures $\tilde{c}$). This is given by equation (2). This function must be increasing whenever it lies below the red curve, and decreasing when the opposite is true. Intuitively, if the agent at the threshold or margin of joining the pool would individually be willing to take more care than the average agent in the pool, then adding that agent to the pool will increase the optimal care level within the pool; adding a marginal type above the average increases the average.

If the pooling region were limited to $[\underline{c}, c']$, then the optimal standard within the pool x'' would be below the optimal care for the threshold type x' (as well as for agents with costs slightly above the threshold). But this (1) violates the requirement that the second-best schedule be decreasing since many excused types exert more care than the pooled types and (2) breaks the needed indifference for the threshold type between pooling and separating. Instead, the cost type where the solid and dashed curves intersect identifies the marker between the objective and tailored standards. At that point, the border type is indifferent. Moreover, with this threshold type, the care level taken by the agents within the pool is maximized.

To understand why, notice that the breadth of the pooling region trades-off two competing forces. On the one hand, broadening the pool increases the average cost within the pool, which causes the optimal pooling care level to decrease, *ceteris paribus*. On the other hand, broadening the pool decreases the probability that agents within the pool will have their effort wasted by being matched to an agent outside the pool (who takes less care). Improved matching reduces the *effective* costs of care and thus increases the optimal pooling care level. The $\hat{c}$ defined by (3) makes this trade-off optimally, resulting in the highest possible care from agents within the pool.

Figure 1: Breadth of the Objective Test



Drawing these insights together, we have the following proposition.

Proposition 2. *Suppose c_m and c_p are independent draws from the same distribution. Then $x_m^{2nd}(c) = x_p^{2nd}(c) = x^{2nd}(c)$. There exists a unique threshold $\hat{c} > \underline{c}$ characterized by $\hat{c} = 2E[c|c < \hat{c}]$, s.t.*

$$x^{2nd}(c) = \begin{cases} z\left(\frac{2E[c|c<\hat{c}]}{G(\hat{c})}\right) = z\left(\frac{\hat{c}}{G(\hat{c})}\right) & \text{if } c \leq \hat{c} \\ z\left(\frac{c}{G(c)}\right) & \text{if } c > \hat{c} \end{cases}$$

Furthermore, $\frac{\partial x^{2nd}(c)}{\partial c} < 0$ whenever $c > \hat{c}$.

These results shed light on a number of phenomena. First, suppose that $\hat{c} \geq \overline{c}$ so that $G(\hat{c}) = 1$. (This will occur if $\overline{c} \leq 2E[c]$.) In that case, the court holds all motorists and all pedestrian's to the same objective benchmark. Related to the discussion above, this standard coincides with the first-best decision rule when: (1) effort decisions are relative complements and (2) a motorist with average costs is paired with a pedestrian with average costs, i.e. $x^{2nd} = z(E(c) + E(c))$. Thus, 'reasonableness' reflects an appeal to the statistical average cost to manage coordination challenges and avoid waste. The planner is not constrained to use the cost of the average agent to determine standards of conduct. Instead, she finds it desirable to do so, given the agents' ignorance about each other.

If $\hat{c} < \overline{c}$, then the second-best care schedule is characterized by partial pooling; agents with low costs are held to an objective standard, while agents with high costs are excused and held to a tailored and lower standard, instead. The optimal pooling care level is a 'modified reasonable person standard." Moreover, this modified standard demands a higher level of care from agents in the pool than would be the case if the pool included all agents. Thus, the availability of excuses not only provides relief to high-cost agents. It also makes certain that low-cost agents are able to provide the highest level of care achievable, given the incentive problems that arise in the private information environment.

For excuses (i.e. tailoring) to arise, we need $\hat{c} < \overline{c}$, which in turn requires that $\overline{c} > 2E[c]$. Given the bounded support, this condition is satisfied when the distribution of costs has a sufficiently long tail relative to the mean cost - i.e. most agents have low costs, but there is a small tail with relatively high costs. As we discuss in a later section, forces that tend to truncate the distribution of costs or abilities, such as licensing requirements, will also make pure reasonable person standards without the possibility of excuses more likely. In Online Appendix A we provide a worked example that illustrates the key ideas discussed above that stem from Proposition 2.

3.A. Doctrinal Implications and Discussion

Now we turn to the legal implications of the analysis. Consider the case establishing the reasonable person standard in tort law, *Vaughn v. Menlove*.[16] In that case, the defendant stacked a hay rick on the edge of his land. His neighbor told him it might catch fire. The defendant responded that he would "chance it." The hay rick ignited and burned down his neighbor's house. The neighbor sued. At trial, the defendant framed the issue as "whether [the defendant] had acted bona fide to the best of his judgment; if he had, he ought not to be responsible for the misfortune of not possessing the highest order of intelligence."

The court refused to relax the standard to account for the defendant's limited intelligence. Instead, the court held the defendant to the standard of ordinary prudence. Presumably, the defendant in *Vaughn* had a higher cost of care than the average person. Yet the court refused to tailor the standard of care to his costs. In fact, the court refused to allow the defendant to even offer proof that he was of below-average intelligence.

Consistent with *Vaughn*, in his famous lectures on the common law, Holmes (1881) honed in on expectations as a reason for objective standards, concerns formalized in the model. He wrote:

> If, for instance, a man is born hasty and awkward, is always having accidents and hurting himself or his neighbors, no doubt his congenital defects will be allowed for in the courts of Heaven, but his slips are no less troublesome to his neighbors than if they sprang from guilty neglect. His neighbors accordingly require him, at his proper peril, to come up to their standard, and the courts which they establish decline to take his personal equation into account.

The bulk of tort cases follow the logic of *Vaughn*. Yet, the law also contains pockets where the standard is calibrated to account for higher costs.

3.A.1. Excuses: Lower Standards

As noted in the introduction, courts assess accident liability for children and individuals with physical disabilities by reference to a standard of care of a child of that age and experience or

[16] 132 Eng. Rep. 490 (1837).

an individual with that specific disability. In deviating from the reasonable person standard, courts more finely tailor the standard to the costs and abilities of the actor in question.

Some examples show how the law reflects the insights in Proposition 2. Consider *Friedman v. State*.[17] The plaintiff was a sixteen-year-old girl who worked as a counselor at a summer camp. On her day off, she took a ski lift with a male colleague to picnic at the top of a mountain. On their way down, the ski resort stopped the chair lift for the night while the plaintiff and her fellow counselor were still on it. Rather than spend the night alone with a male, the plaintiff jumped off the lift, sustaining injuries. The issue was whether her conduct rendered her contributorily negligent and therefore ineligible for relief.

In finding for the plaintiff, the court followed the customized standard for children, stating, "In evaluating the issue of contributory negligence, as it related to this infant, the fact of freedom from negligence is even more evident when we consider her age, judgment, experience, and education." The court further commented on the characteristics of that particular plaintiff, opining:

> [I]t does not require much imagination or experience to determine that a lightly dressed 16-year-old city girl might become hysterical at the prospect of spending a night on a mountainside, suspended in the air and with no apparent reason to hope for rescue until the next morning. Secondly, we must add to the fact of expectable hysteria, the moral compulsion *this* young lady believed she was under, not to spend a night alone with a man. *Id.* at 862 (emphasis added)

Because she was a minor, the *Friedman* court held the plaintiff to a finely tailored appropriate to her subjective circumstances, even though these traits were likely unknown to the defendant, and quite likely difficult to observe.

In practice, tort law uses proxies of age and disability to identify those with high costs. To make our point cleanly, we made the unrealistic assumption that the court could observe costs perfectly. In practice, courts might find it administratively less costly to rely on simple markers to identify "classes" of individuals who usually have higher costs and thus should be eligible for relief from the reasonable person standard.

[17] 282 N.Y.S.2d 858 (Ct. Cl. 1967).

3.A.2. Heightened Standards: Torts

While the law can be forgiving of actors with high costs, it is often not extra demanding of actors with low costs. In *Fredericks v. Castora*,[18], for example, the plaintiff was a passenger in a truck driven by an experienced trucker. The driver made a U-turn across four lanes of traffic and, in so doing, was struck by another truck, causing injury to his passenger. The plaintiff argued that the driver was expert and experienced. Accordingly, he should be held to a higher standard of care than the typical driver. The court refused to do so. In defining the duty the truck driver owed to other drivers, the court did not allow evidence of a lower cost of care into the proceeding, a holding consistent with the model's predictions.[19]

Although followed by most jurisdictions, this position is open to debate. For example, in *Everett v. Bucky Warren, Inc.*,[20] a hockey coach supplied his team with helmets that came in three separate sections, linked together by straps. A puck struck the plaintiff between the sections, causing injury. Unlike *Fredericks*, the court held the coach to a heightened standard of care, stating "[the coach], as a person with substantial experience in the game of hockey, may be held to a higher standard of care and knowledge than would an average person."[21]

The model sheds light on the proper tort rule. Courts should exercise caution before raising the standard for the skillful, especially when coordination is necessary: *Fredericks* represents a better rule than *Everett*.

3.A.3. Heightened Standards: Special Relationships and Control

At common law, heightened standards—in the rare cases where they did arise—involved common carriers, innkeepers, and some fiduciaries.[22] In all these situations, one actor forfeits control to a second actor, muting coordination concerns. Accordingly, we should expect more tailored standards.

[18] 360 A.2d 696 (1976).

[19] The same result ayose in *LaVine v. Clear Creek Skiing Corp.*, 557 F.2d 730 (10th Cir. 1977). There, a ski instructor crashed into the plaintiff while skiing. The plaintiff sought a jury instruction that a ski instructor should be held to a higher level of care, given his expertise. The court rejected the invitation.

[20] 376 Mass. 280 (1978).

[21] Id. at 288; American Law Institute (1965, §289(c)).

[22] See, e.g., *Connell's Ex'rs v. Chesapeake & O. Ry. Co.*, 93 Va. 44, 55 (1896) (holding railroads, as common carriers, to the standard of utmost care and diligence); *Taboada v. Daly Seven, Inc.*, 271 Va. 313, 326 (2006)(holding innkeepers to the elevated duty of utmost care and diligence to protect a guest from third party criminal conduct on the innkeeper's property); *In re Killey's Est.*, 457 Pa. 474 (1974) (holding fiduciary's standard of care to the level of skill they have or claimed to have, rather than that of a man of ordinary prudence).

Consider, for example, liability for accidents involving common carriers, such as trains, buses, or other modes of transport open to the public. After the passenger boards, there is little she can do to prevent a crash. In these circumstances, the common law demands that the carrier exercise the "utmost" care, a heightened obligation to provide safe passage.[23]

In deciding if a defendant is, in fact, a common carrier, i.e., whether to use a heightened standard, courts ask if the behavior of a single party or the combination of the behavior of multiple parties determines the materialization of an accident. This logic behind this question is consistent with coordination as one touchstone for using the reasonable person standard.

For instance, the court in *Nalwa v. Cedar Fair, L.P.*,[24] distinguished between a roller coaster ride (deemed a common carrier) and a bumper car ride (deemed not). The court opined:

> A roller coaster is constrained to a track and subject to the exclusive control of the operator. Those choosing to ride a roller coaster surrender[ ] themselves to the care and custody of the [operator]; they...give[ ] up their freedom of movement and actions..." In contrast, a bumper car ride...consists of small electric cars that operate at medium speeds around a flat surface track....[the amusement park] maintain[s] and inspect[s] the ride; set[s] maximum speeds for the minicars; [the employees] load and unload riders; activate the ride; ... and enforce various riding instructions and safety rules. But once the ride commences, patrons exercise independent control over the steering and acceleration of the cars. Unlike roller coaster riders, they do not surrender their freedom of movement and actions.

3.B. Decoupling Policy and Application

As a direct consequence of expression (3), we have the following corollary:

Corollary 1. *The threshold $\hat{c}$ can be determined without reference to the accident reduction technology* Π *and the conduct required under the standard.*

[23] *Fairchild v. California Stage Co.*, 13 Cal. 599, 604 (1859)("[I]t has been accordingly held that passenger-carriers bind themselves to carry safely those whom they [admit] into their coaches, as far as human care and foresight will go, that is, for the utmost care and diligence of very cautious persons; and of course they are responsible for any, even the slightest, neglect.").

[24] 55 Cal. 4th 1148, at 1161

The standard of care $x(c)$ that the court assigns to an agent will depend on the accident reduction technology Π (through the function $z(c) = [\Pi']^{-1}(-c)$). This dependence on Π is reflected in the instruction to juries to assess the agents' conduct "under the circumstances." Conduct that might have been reasonable on a sunny day might not remain so during a snow storm.[25] The Corollary shows that neither this mapping, nor the circumstances prevailing in the case at hand, bear on whether to hold a particular agent to the pooling standard or to offer them an excuse. The intuition again stems from the nature of the adverse selection problem; if the purpose of pooling is to mitigate the problem of there being too many lemons in pool, then the extent of pooling will depend on the distribution of types, and not the external technology that maps types into choices.

This dis-aggregation has implications for institutional design. An institution can separate **policy** decisions—who gets leniency?—from **application**—what should the standard be and did the agent meet it? In so doing, the institution can then assign different decision rights to different actors.

For example, an institution might consist of a high-level policymaker and a cadre of low-level "managers." The policy-maker decides who is excused from hitting objective benchmarks and who is not. The "managers" can then use local knowledge to compute the needed benchmark against which behavior (for both pooled and excused workers) is judged.

As noted briefly in the introduction, tort law reflects this design choice. To prevail on a tort claim, the plaintiff must prove that the defendant owned the plaintiff a duty and that the defendant breached that duty. The judge decides the "duty" question: whether the defendant should be held to the reasonable person standard or granted a reprieve and held to a lower standard. The jury decides the breach question: whether the defendant acted as a reasonable person (possibly subject to an excuse) would "under like circumstances."

Like us, prior models of accidents specify the standard of care as the result of minimizing social costs. These models do not specify which institutional actors, judge or jury, should decide liability. They do not separate breach from duty. The reason is that, unlike us, prior work does not confront the difficulty of coordinating behavior in the face of asymmetric information between strangers.

Notably, Corollary 1 also implies that, while the standard required to be deemed non-negligent may vary across time and accident types, the frequency with which the court

[25] See *Staunton v. City of Detroit*, 46 N.W.2d 569, 573 (1951)('[T]he proofs in the case indicate that at the time of the accident weather conditions were such as to require special care and caution on the part of the driver of defendant's bus.").

grants excuses from that standard should not. This insight contributes to a longstanding debate in tort law: why are courts resistant to extending excuses to new classes of individuals? For example, scholars and advocates have lobbied courts to apply a more lenient standard of care for the mentally disabled (Dark, 2004; Eggen, 2015; Lindquist, 2020). Courts have refused, reasoning that mental disability is easier to fake than physical disability.[26] But because of advances in mental health diagnosis, this argument is less persuasive today. Indeed, courts do take account of mental disability and insanity for determining criminal culpability.[27] This analysis identifies an under-appreciated difference between criminal law and tort law. Crimes are much less likely to involve coordinating behavior, and thus the need to fix the expectation of others—our key driver—becomes less important.

As indicated, prior work justifies the reasonable person standard as a response to the court's costs of measuring differences in aptitude. Under that view, we might expect, over the long run, that improvements in the measurement technology should be reflected in changes in the standard. Yet, as noted, the law has not followed this theme. Our model, by contrast, predicts stability in the classes of excused actors.

3.C. Comparative Statics

We now turn to comparative statics as to the breadth of the pooling region and the breadth of the excuse region. Both of these regions depend on the location of $\hat{c}$, which in turn depends on the distribution of costs $G(c)$.

To do comparative statics on the properties of that distribution, let $c \sim G$ and $c \sim H$ denote two different distributions from which both the pedestrian's and motorist's cost are drawn. Let $\hat{c}_G$ and $\hat{c}_H$ be the corresponding thresholds for both the motorist and the pedestrian. Recall that these thresholds are defined by $2E_i[c|c < \hat{c}_i] = \hat{c}_i$ for each $i \in \{G, H\}$, so that the comparative static results largely depend on the behavior of the conditional expectation as the distribution changes. We have the following results:

Lemma 1. *The threshold $\hat{c}$ is responsive to the distribution of costs in the following way:*

[26] See *Creasy v. Rusk*, 730 N.E.2d 659, 66 (Ind. 2000)("The public policy reasons most often cited for holding individuals with mental disabilities to a standard of reasonable care in negligence claims include . . . [It] removes inducements for alleged tortfeasors to fake a mental disability in order to escape liability."). See also Restatement (Second) of Torts Â§ 283B cmt. b(2).

[27] See State v. Searcy, 798 P.2d 914, 917 (1990); Model Penal Code, Â§ 4.01 ("(A) person is not responsible for criminal conduct if at the time of such conduct as a result of mental disease or defect he lacks substantial capacity to appreciate the criminality (wrongfulness) of his conduct or to conform to the requirements of the law."

1. ***Scaling***: *Suppose* $c_H = \kappa c_G$ *with* $\kappa > 0$. *Then* $\hat{c}_H = \kappa \hat{c}_G$, *and* $H(\hat{c}) = G(\hat{c})$. *The threshold scales and the probability of excuses is unchanged.*

2. ***Mean Preserving Spread***: *Suppose that (a)* H *is a MPS of* G, *and (b)* $H(\hat{c}_G) < G(\hat{c}_G)$ *(i.e. the* c_G *standard applied under the spread distribution produces more excuses). Then* $\hat{c}_H < \hat{c}_G$, *and* $H(\hat{c}_H) < H(\hat{c}_G) < G(\hat{c}_G)$. *There will be more excuses.*

The scaling comparative static teaches us, unsurprisingly, that the units of cost measurement do not impact the probability of an excuse. The mean preserving spread result is of more interest. The court cares about (a) the average cost of those agents in the pool and (b) the possibility of waste. By contracting the pool size, the planner decreases the average cost of pool members while increasing the probability of waste.

The reshuffling of agent types under a mean preserving spread makes shrinking the pool attractive. The reason is that the pool has many more low-cost agents in it (and thus a lower average cost). Thus, the planner gladly tolerates an increased chance of mismatched effort to tap into the lower average cost of care in the pool. It does so by assigning a higher standard of care among those subject to the objective standard. In obtaining this result, we restrict attention to the most natural setting, cases where excuses are rare —implying that a mean preserving spread will push more agents into the region of excuses.

Observe the analog to licensing. A licensing requirement prohibits high-cost actors from engaging in the activity. Our model provides a new justification for this prohibition. With fewer individuals at the high-cost end, coordination becomes less of a challenge. The planner then can restrict the pool size. With a smaller pool, the planner optimally imposes a higher standard of conduct on anyone subject to the objective standard. This idea finds support in the law: licensed professionals are held to a higher standard of care than unlicensed occupations. Further, a pure reasonable person standard will be more likely applied in situations where licensing occurs, and the availability of excuses will likely be curtailed.

3.D. Generalizations

Having explored the baseline case, we now turn to more general settings. We first extend the results to the case where care decisions are imperfect complements, retaining the assumption that costs are drawn from identical distributions. Next, we derive results assuming non-identical distributions of costs, but retaining the assumption of perfect complements.

3.D.1. Imperfect Complements

In the baseline case, excess care was wasted whenever an agent took more care than her counterparty. With imperfect complements, excess care is no longer completely wasted; it still reduces the probability of harm, though the size of the harm reduction may be small.

The court might nonetheless wish to coordinate the efforts of agents with different costs because the gain of having the lower-cost type take more care, though positive, is not worth the additional cost. Formally, we have the following result:

Proposition 3. *For every $\lambda \in [0, 0.5]$, there exists $\hat{c}(\lambda) \geq \underline{c}$, such that the second-best schedule applies an objective standard $\hat{x}(\lambda)$ to all agents with costs $c < \hat{c}(\lambda)$. Additionally, $\hat{c}(\lambda)$ is strictly decreasing in λ. Finally, if $\lambda = 0$ (perfect complements) then $\hat{c}(0) = 2E[c\,|c < \hat{c}]$, and if $\lambda = .5$ then $\hat{c}(0.5) = \underline{c}$.*

Proposition 3 demonstrates that our results do not turn on the strong assumption of perfect complements. Generically, for any degree of substitutability/complementarity, the optimal second-best schedule will apply an objective standard to the low-cost agent and excuse the conduct of the highest-cost agents. The breadth of the pooling interval, however, narrows as the agents' care becomes increasingly substitutable. In the perfect substitutes limit, the pooling region disappears entirely.

Stated differently, if the technology is such that consequences of recklessness by one party can be easily rectified by having the counter-party be extra careful, the legal regime should entail (1) more and more tailoring and (2) higher objective markers for those with a relatively low cost of care.

This comparative static tracks legal doctrine. For example, investment advisors come in various types: registered investment advisors, broker-dealers, and unregistered financial planners. If identifying the appropriate investment vehicle can be done by efforts of the investor or the advisor, the imperfect complements proposition applies, and we should see, in effect, some advisors held to a very high objective standard with declining obligations for the less able. The law governing financial advisors follows this pattern.

Registered investment advisors are fiduciaries and held to the highest standard of care. They must "serve the best interest of the client and not subordinate the client's interest to their own." Broker-dealers, by contrast, are held to a lower standard of "suitability," meaning that "the advisor has a reasonable basis to believe a recommended transaction or investment strategy involving a security or securities is suitable for the customer." Unregistered financial planners are held to a still lower standard of "reasonableness."

Pivoting back to the model, next consider the implication of Proposition 3 for the emergence of a pure reasonable person standard, the case where the court ignores all cost information in setting the standard. Recall, in the case of the perfect complements, the court disregards all personalized cost information, and holds *all* agents to the same standard when $\hat{c}(0) > \overline{c}$ (which occurs when $\overline{c} < 2E[c]$). Further, this standard aligns with the first-best standard when matching the average pedestrian and the average motorist. The same remains true as the care technology becomes somewhat substitutable. We formalize this result in Corollary 2 below.

Corollary 2. *Suppose $\overline{c} < 2E[c]$, so that under perfect complements, the second-best schedule is a pure objective rule. Then, there exists $\overline{\lambda} = 1 - \frac{\overline{c}}{2E[c]} > 0$, such that the second-best schedule remains a pure objective rule for all $\lambda < \overline{\lambda}$ (equivalently, if $\overline{c} < 2(1-\lambda)E[c]$). Moreover, this objective standard is the reasonable person standard $\hat{x}(\lambda) = z(2E[c])$.*

Finally, turn to the separation of policy and application. The baseline case showed that decisions about the breadth of the pooling region could be made independently from decisions about the conduct demanded under the standard. That result extends:

Corollary 3. *With imperfect complements, the location of $\hat{c}(\lambda)$ is independent of the accident reduction technology Π.*

3.D.2. Non-Identical Distributions

Let us return to the perfect complements environment. Suppose that the motorist and pedestrian draw costs from the different distributions. Let $G_m(c)$ and $G_p(c)$ be two different continuous distributions satisfying the assumption previously described.

Because the distributions are different, the second-best care schedules, $x_m(c_m)$ and $x_p(c_p)$, will have different shapes. More, the motorist and the pedestrian will have different pooling thresholds.

Given these complications, some new notation helps explicate the results. With perfect complements, the motorist with cost c_m must estimate the probability that the pedestrian he encounters will take less care. Define the pedestrian type $c_p(c_m)$ as the pedestrian who the court induces through legal rules to take the same care as the motorist with cost c_m;

that is, $x_m(c_m) = x_p(c_p(c_m))$. In the separating region, if it exists, the first-order conditions imply

$$x_m(c_m) = z\left(\frac{c_m}{Pr(x_p(c_p) > x_c(c_m))}\right) = z\left(\frac{c_m}{G_p(c_p(c_m))}\right)$$
$$x_p(c_p(c_m)) = z\left(\frac{c_p(c_m)}{Pr(x_m(c_m) > x_p(c_p(c_m)))}\right) = z\left(\frac{c_p(c_m)}{G_m(c_m)}\right),$$

where we use the fact that schedules are locally invertible. By construction $x_m(c_m) = x_p(c_p(c_m))$ and thus we can define the function $c_p(c_m)$ implicitly by:

$$c_m G_m(c_m) = c_p G_p(c_p).$$

We can analogously define $c_m(c_p)$, and note that $c_p(c_m)$ and $c_m(c_p)$ are inverse functions. The next result generalizes of Proposition 2:

Proposition 4. *There exist threshold $\hat{c}_m > \underline{c}_m$ and $\hat{c}_p > \underline{c}_p$ uniquely defined by:*

1. *$\hat{c}_m = c_m(\hat{c}_p)$ (or equivalently, $\hat{c}_p = c_p(\hat{c}_m)$), and*
2. *$\frac{E[c_m \mid c_m < \hat{c}_m]}{\hat{c}_m} + \frac{E[c_p \mid c_p < \hat{c}_p]}{\hat{c}_p} = 1$*

such that:

$$x_i^{2nd}(c_i) = \begin{cases} z\left(\frac{E[c_m|c_m<\hat{c}_m]}{G_p(\hat{c}_p)} + \frac{E[c_p|c_p<\hat{c}_p]}{G_m(\hat{c}_m)}\right) & \text{if } c_i < \hat{c}_i \\ z\left(\frac{c_i}{G_{-i}(c_{-i}(c_i))}\right) & \text{if } c_i \geq \hat{c}_i \end{cases}$$

Proposition 4 is a natural generalization of Proposition 2. In the region of excuses, the agent chooses the unilaterally best care level given their *effective* cost. Modified costs simply inflate the agents true cost by the inverse of the probability that the opponent takes more care. Since the opponent with cost $c_{-i}(c_i)$ takes the same care level of agent i with cost c_i, the modifier term is simply $G_{-i}(c_{-i}(c_i))$. Similarly, in the pooling region, the agents coordinate upon the optimal first-best care level given the expected *effective* costs of the agents in the pool. Yet again, when there is complete pooling (which will occur whenever $\max\{\overline{c}_m, \overline{c}_p\} < E[c_m] + E[c_p]$), all agents will be held to a common reasonable person standard, which is simply the first-best standard when applied to the average motorist and average pedestrian, having costs $E[c_m]$ and $E[c_p]$, respectively.

4 Implementation: Designing the Legal Rules

The analysis so far has focused exclusively on the planner's problem identifying the optimal care levels for the motorist and pedestrian, constrained by the information those agents possess at the time they act. But are these optimal choices implementable, and, in particular, are they implementable under the standard liability rules used by courts? The answer is yes. The standard logic from Shavell (1987) applies.

Take two common liability rules utilized by courts: a pure negligence rule and a strict liability rule with a defense of contributory negligence.[28] The pure negligence rule holds the defendant liable for harm suffered by the plaintiff only if the defendant took less than due care. Define due care as the care level from the second-best analysis above. A motorist, say, will be liable if they take less than $x_m^{2nd}(c_m)$. Clearly, the motorist will not take more care than the court demands because she bears the additional cost for no additional benefit. If, however, she takes a smidge less, she will be fully liable for the injury. The negligence rule thus creates a discontinuity in the motorist's payoff as a function of their care decision. The discontinuity induces the motorist to take $x_m^{2nd}(c_m)$ and thereby avoid liability. As a result of the motorist's decision, the pedestrian becomes the residual claimant and acts to minimize the sum of her precaution costs and accident losses. Doing what the court desires achieves this result.

A strict liability rule with a defense of contributory negligence holds the defendant liable for the harm unless the *plaintiff* took less than due care. The same discontinuity logic described above induces the pedestrian to take $x_p^{2nd}(c_p)$. Given that the pedestrian will never be responsible for the harm, the motorist becomes the residual claimant. As a result, the motorist acts to minimize the sum of her precaution costs and accident losses. The minimizing care level is the second-best care level. In equilibrium, both agents take the care associated with the second best schedules.

The two rules are broadly similar, and differ only in which agent is held to be the residual bearer of harm. Collecting these insights, we have the next proposition.

[28] On negligence, see *Solv-All v. Superior Ct.*, 131 Cal. App. 4th 1003, 1010 (2005) ("in our body of law the term 'negligence' implies a careless, but unintentional, failure to act with due care"); on strict liability with a defense of contributory negligence, see Oltz v. Toyota Motor Sales, 166 Mont. 217, 220 (1975)("[I]n a strict liability case involving an alleged manufacturing defect that was unknown to the operator and which apparently had nothing to do with causing the accident in question but merely contributed to the operator's injuries, his own contributory negligence in the operation of the vehicle so as to cause it to leave the highway is a proper defense.").

Proposition 5. *A pure negligence rule and a strict liability rule with contributory negligence will both implement the second-best schedules* $(x_m^{2nd}(c_m), x_p^{2nd}(c_p))$*. Formally, consider*

- *A pure negligence rule that establishes a standard of care for the defendant (i.e. the motorist)* $x_m^{2nd}(c_m)$*.*
- *A strict liability rule with a defense of contributory negligence that establishes a standard of care for the plaintiff (i.e. the pedestrian)* $x_p^{2nd}(c_p)$*.*

Under either rule, it is Nash equilibrium for both agents to take their second-best care level.

We have assumed the court can observe the actors' costs perfectly. This is not strictly necessary. Emmons and Sobel (1991) show that the second-best schedules can be implemented as a Nash equilibrium of a game between the motorist and pedestrian so long as society allows for sufficiently rich liability rules (including the possibility of punitive damages).

5 Extensions and Limitations

5.A. Central Tendency Technology

The main analysis relied on an Order Weight Average technology to express complements and substitutes in care. The technology is attractive for its simplicity. Also, as noted, unlike the more familiar CES technology, the OWA technology allows for a parameter that meaningfully captures complementarity even when the actors take similar levels of care. The isoquants for this technology are piecewise linear and has a kink when the actors take the same level of care. Online Appendix B shows that the linearity assumption can be relaxed without altering the results. Non-differentiability is a more important feature. Yet the insights obtained with this simple technology extend without much loss of generality. Let us explain.

Take, for instance, the smoother CES technology. When the CES function represents perfect complements ($\rho \to -\infty$), we have the same result as derived in section 3; there is a region of pooling possibly coupled with tailoring for the highest cost types. Moving away from perfect complements, with the CES technology, the second-best care schedule becomes strictly decreasing, and the pooling result formally disappears. However, it is easily shown that the second-best schedule $x(c;\rho)$ is continuous in the CES parameter ρ, and so with imperfect complements, the second-best schedule will be relatively flat for low levels of cost and relatively steep for high levels of cost.

Now suppose the planner paid a small price for imposing differential standards on actors with costs that were very close together. The efficiency benefits of making those distinctions for actors with costs below $\hat{c}$ are tiny because the optimal schedule has a fairly flat slope. In the excuse region, by contrast, the efficiency benefits from making distinctions among types are much higher because the care schedule dictates that the law induces much different care decisions for each type (the schedule's slope is quite negative). Thus, the non-differentiable schedules associated with our model mirror the schedules in second-best with the CES function under the assumption that the planner pays a small cost to make fine distinctions between agent types.

5.B. Application to Contract Law

Though we motivated the model through a discussion of accident law, by a simple re-characterization of the problem, the insights can be applied in other contexts. Take a contract between a buyer and seller. The buyer's valuation is unknown to the seller, and the seller's cost is unknown to the buyer. Both the buyer and seller make investment choices that increase the gains from trade. The parties write a contract to maximize the gains from trade. We formalize this model and provide results in Online Appendix C.

Suppose the court can observe the seller's cost and the buyer's valuation ex-post. Should the contract dictate tailored or objective standards for the investment? That is to say, should the contract hold the buyer with a high valuation or the seller with a low cost to higher investment markers? The same trade-off arises. The seller with low costs effectively wastes her hefty investment if the buyer realizes a low valuation. Likewise, a buyer with a high valuation wastes her significant effort if matched with a seller with a high cost of effort. And so, the contract should mandate objective rather than tailored standards for low-cost sellers and high-valuations buyers. Further, the contract should excuse skimpy investment choices by a buyer with a low valuation or a seller with a high cost.

Contract law reflects these ideas. Consider two examples of default rules, rules that are designed to maximize the gains from trade when the parties leave gaps in a contract.

5.B.1. Good Faith and Formation

Under the Uniform Commercial Code, every contract includes an obligation of good faith in its enforcement and performance.[29] Good faith means "honesty in fact" and "observations of reasonable commercial standards of fair dealing."[30] The good faith standard considers the particularities of the transaction and what happened between the parties. In this way, good faith inquiries are finely tailored to the transaction at issue.

Notably, the good faith obligation does not apply during contract formation when the parties are deciding to be bound or not. At formation, the court asks whether a "reasonable" party in the position of, say, the offeree would conclude an offer has been made.[31] Why the discord?

Our model provides an explanation. During formation, the parties do not know much about each other. In this context, reasonableness induces coordination of efforts and waste avoidance. It assures that both parties adequately invest—but do not over-invest—in communicating their needs and desires. After the parties have formed a contract, their ongoing relationship enables each party to better learn about the other. As the information asymmetry vanishes, the parties can root the seller's obligations in the seller's actual cost and the buyer's actual valuation (which the seller now knows). Doing so induces an efficient (first-best) level of investment. The good faith standard effectuates that goal.

5.B.2. Conditions Involving Taste, Judgment and Fancy

Contracting parties often condition performance on the triggering of uncertain events. A buyer, say, might condition his obligation to buy a piece of property on his ability to obtain financing. The buyer then might have to make some investment in securing financing. But how much is required under the contract? How hard must the buyer try to find a lender? Similarly, a restaurant owner might condition its obligation to have an ongoing relationship with a live music band on its satisfaction with the band's performance. How much effort must the owner spend working and promoting the band?[32]

On the one hand, when the condition involves "taste, fancy, or judgment," the law applies a more personalized good faith standard. The question is whether the specific restaurant

[29] U.C.C. 1-304.

[30] U.C.C. 1-201.

[31] In re JGB Indus., Inc., 223 B.R. 901, 907 (Bankr. E.D. Va. 1997)("The content of the offer will be construed from the standpoint of a reasonable person in accordance with the objective theory of contract formation.").

[32] See Ferris v. Polansky, 191 Md. 79, 82, 59 A.2d 749, 750 (1948).

owner was satisfied with the band or the specific buyer found obtaining financing difficult. On the other hand, when the condition involves satisfaction with the mechanical fitness, utility, or marketability of the goods, the law applies the reasonable person standard.[33] Why this distinction? The model provides one possible answer.

According to Lemma 1 above, a mean preserving spread of the buyer's valuation should result in a more tailored law. To the extent that transactions rooted in "taste, fancy, or judgment" involve a larger spread, the common law's reliance on reasonableness for conditions involving mechanical utility and shying away from reasonableness in taste, judgment, and fancy cases makes some sense.

6 Concluding Remarks and Discussion

Debate about the law's reliance on the reasonable person standard has been simmering for years. On one side sits the philosophers. They claim that the reasonable person standard embeds into the law notions of reciprocity, fairness, and the proper expectations of the behavior of others. On the other side sits the law and economics scholars. They argue that the reasonable person standard arises because courts find it expensive to measure cost on an individual basis. The court, then, avoids doing so by treating everyone the same.

The two camps largely talk past each other. This model provides economic content to the philosopher's position. It explains (a) when expectations about the behavior of others matter and (b) how a legal rule consisting of an objective standard with releases for the least able in the population leads to a proper construction of those expectations and a superior allocation of resources.

The model sheds light on many doctrinal features and institutional arrangements that other models cannot fully explain. These include:

- **Separating Decisions about Duty from Decisions about Breach**

  Judges decide the question of duty (what the standard should be), and jurors decide the question of breach (whether the defendant satisfied the standard).

[33] See McKendrie v. Noel, 146 Colo. 440, 441, 362 P.2d 880, 881 (1961). In this case, a contract called for delivery of an automatic rug-cleaning machine. In deciding whether the sale should be consummated, the court examined whether a reasonable person would conclude the rug cleaning machine worked as promised.

- **Heightened Standards and Control**

  The common law deploys heightened standards of care where one party "controls" the environment. The heightened standard arises, we suggest, exactly in the circumstances without coordination concerns. Prescriptively, the model suggests that the law should not adjust the standard upward for defendants with superior aptitude unless the plaintiff can also prove a lack of coordination concern (for example, by showing control).

- **Finely Tailored Excuses**

  For those granted leniency from the reasonable person standard—children and the physically disabled—the standard tends to be more finely tailored.

- **Changes in Measurement Costs**

  The model shows that reasonableness is an attractive standard, even when ex post measurement costs go to zero. This implies, normatively, that spending more and more money to collect individualized information about specific individuals is unlikely to lead to different standards of care, and thus might not be cost-justified.

Notably, the expectations concern strikes hardest where care decisions are strong complements. In those cases, the adverse selection problem is most acute, and so is the need for the antidote of the objective standard. The urge to be "reasonable" arises as a way to facilitate coordination and avoid waste. The cost is a failure to fully utilize the talents of high-ability actors.

Finally, the model made several assumptions. Most importantly, we assumed that the parties interacted only one time. With repeated interactions (like with the buyer and seller in a relational contract), the actors would learn about each other's costs over time. The law would then need to be responsive to this learning dynamic. We hope to consider this extension in future work.

References

American Law Institute. (1965). *Restatement of the law, second, torts 2d.* American Law Institute Publishers.

Avilés-Ochoa, E., León-Castro, E., Perez-Arellano, L. A., & Merigó, J. M. (2018). Government transparency measurement through prioritized distance operators. *Journal of Intelligent & Fuzzy Systems*, *34*(4), 2783–2794.

Ben-Shahar, O., & Porat, A. (2016). Personalizing negligence law. *New York University Law Review*, *91*(3), 627–688.

Bernheim, B. D., & Whinston, M. D. (1998). Incomplete contracts and strategic ambiguity. *American Economic Review*, *88*(4), 902-932.

Blanco-Mesa, F., León-Castro, E., & Merigó, J. M. (2018). Bonferroni induced heavy operators in erm decision-making: A case on large companies in colombia. *Applied Soft Computing*, *72*, 371–391.

Brown, J. P. (1973). Toward an economic theory of liability. *Journal of Legal Studies*, *2*, 323–349.

Calabresi, G., & Hirschoff, J. T. (1971). Toward a test for strict liability in torts. *Yale Law Journal*, *81*(6), 1055–1085.

Che, Y.-K., Dessein, W., & Kartik, N. (2013). Pandering to persuade. *American Economic Review*, *103*(1), 47–79.

Cremer, J. (1995). Arm's length relationships. *Quarterly Journal of Economics*, *110*(2), 275-295.

Dark, O. C. (2004). Tort liability and the unquiet mind: A proposal to incorporate mental disabilities into the standard of care. *Thurgood Marshall Law Review*, *30*(1), 169–214.

Demsetz, H. (1972). When does the rule of liability matter? *Journal of Legal Studies*, *1*, 13-28.

Dobbs, D., Hayden, P., & Bublick, E. (2015). *Hornbook on torts* (2nd ed.). West Academic Publishing.

Doña, J. M., la Red, D. L., & Peláez, J. I. (2009). A mix model of discounted cash-flow and owa operators for strategic valuation. *International Journal of Interactive Multimedia and Artificial Intelligence*, *1*(2).

Eggen, J. M. (2015). Mental disabilities and duty in negligence law: Will neuroscience reform tort doctrine medical myths: Exploring effectiveness, misinformation and scientific rigor. *Indiana Health Law Review*, *12*(2), 591–650.

Emmons, W., & Sobel, J. (1991). On the effectiveness of liability rules when agents are not identical. *Review of Economic Studies*, *58*(2), 375-390.

Faravelli, M., Man, P., & Walsh, R. (2015). Mandate and paternalism: a theory of large elections. *Games and Economic Behavior*, *93*, 1–23.

Garoupa, N., & Dari-Mattiacci, G. (2007). Least cost avoidance: The tragedy of common safety. *Journal of Law, Economics, & Organization*, *25*(1), 235-261.

Holmes, O., Jr. (1881). *The common law*. Dover Publications.

Hurwicz, L. (1951). The generalized bayes minimax principle: a criterion for decision making under uncertainty. *Cowles Comm. Discuss. Paper Stat*, *335*, 1950.

Keating, G. C. (1995). Reasonableness and rationality in negligence theory. *Stanford Law Review*, *48*(2), 311–384.

Landes, W. M., & Posner, R. A. (1987). *The economic structure of tort law* (1st ed.). Harvard University Press.

León-Castro, E., Avilés-Ochoa, E., & Gil Lafuente, A. M. (2016). Exchange rate usd/mxn forecast through econometric models, time series and howma operators. *Economic Computation and Economic Cybernetics Studies and Research*, *50*.

León-Castro, E., Espinoza-Audelo, L. F., Merigó, J. M., Gil-Lafuente, A. M., & Yager, R. R. (2020). The ordered weighted average inflation. *Journal of Intelligent & Fuzzy Systems*, *38*(2), 1901–1913.

Lindquist, G. (2020). Science or status quo? disregard for a defendant's mental illness in tort suits. *Washington Law Review Online*, *95*, 115–167.

Merrill, I. (1985). Landlord liability for crimes committed by third parties against tenants on the premises. *Vanderbilt Law Review*, *38*(2), 431.

MSBNA Standing Committee on Pattern Jury Instructions. (2009). *Maryland civil pattern jury instructions* (4th ed. ed.). Md Institute for the Continuing Prof Ed of Lawyers, Inc.

Posner, R. A. (2014). *Economic analysis of law* (9th ed.). Aspen Publishing.

Rothschild, M., & Stiglitz, J. E. (1970). Increasing risk: I. a definition. *Journal of Economic theory*, *2*(3), 225–243.

Sappington, D. E. M. (1986). Commitment to regulatory bureaucracy. *Information Economics and Policy*, *2*(4), 243–258.

Schelling, T. C. (1980). *The strategy of conflict* (Rev. ed. ed.). Harvard University Press.

Shavell, S. (1987). *Economic analysis of accident law*. Harvard University Press.

Taylor, C. R., & Yildirim, H. (2011). Subjective performance and the value of blind evaluation. *Review of Economic Studies*, *78*(2), 762-794. Retrieved from https://www.jstor.org/stable/23015873

Terry, H. T. (1915). Negligence. *Harvard Law Review*, *29*(1), 40–54.

Xiong, W., & Liu, H. (2014). On solving some paradoxes using the ordered weighted averaging operator based decision model. *International journal of intelligent systems*, *29*(1), 1–25.

Yager, R. R. (2002). On the valuation of alternatives for decision-making under uncertainty. *International Journal of Intelligent Systems*, *17*(7), 687–707.

Yager, R. R. (2004). Uncertainty modeling and decision support. *Reliability Engineering & System Safety*, *85*(1-3), 341–354.

Zipursky, B. C. (2015). Reasonableness in and our of negligence law. *University of Penn-*

sylvania Law Review, *163*(7), 2131–2170.

Proofs

Proof of Proposition 1. Without loss of generality, suppose $c_m < c_p$. Then, it must be that $x_m \geq x_p$. (To see this, note that if $x_m < x_p$, we can achieve the same average cost of care — and hence the same probability of harm — by reversing the care levels, but at lower total cost.)

Suppose $x_m > x_p$. Then, the planner's problem is:

$$W = \min_{x_m, x_p} \Pi(\lambda x_m + (1-\lambda)x_p) + c_m x_m + c_p x_p$$

The first order conditions (FOCs) are:

$$\begin{aligned} \frac{\partial W}{\partial x_m} &= \lambda \Pi'(\lambda x_m + (1-\lambda)x_p) + c_m \geq 0 \\ \frac{\partial W}{\partial x_p} &= (1-\lambda)\Pi'(\lambda x_m + (1-\lambda)x_p) + c_p \geq 0 \end{aligned}$$

Moreover, if $x_i > 0$, then $\frac{\partial W}{\partial x_i} = 0$, and if $\frac{\partial W}{\partial x_i} > 0$, then $x_i = 0$.

Since $x_m > x_p$ by assumption, then $x_m > 0$, and so $\frac{\partial W}{\partial x_m} = 0$. Notice that the Π' term is common to both FOCs. This means that, except for knife-edge cases, it cannot be that both FOCs hold to zero simultaneously. Hence, we must have $\frac{\partial W}{\partial x_m} = 0 < \frac{\partial W}{\partial x_p}$ and so $x_p = 0$. Since the first equation holds with equality, we have:

$$\begin{aligned} \lambda \Pi'(\lambda x_m) &= -c_m \\ x_m &= \frac{1}{\lambda}[\Pi']^{-1}\left(-\frac{c_m}{\lambda}\right) = \frac{1}{\lambda} z\left(\frac{c_m}{\lambda}\right) \end{aligned}$$

Next, substituting out for the common term, the second equation will be positive provided that:

$$\begin{aligned} c_p + (1-\lambda)\left(-\frac{c_m}{\lambda}\right) &> 0 \\ \lambda &> \frac{c_m}{c_m + c_p} \end{aligned}$$

If this condition is not met (i.e. if $\lambda \leq \frac{c_m}{c_m+c_p}$) then asserting $x_m > x_p$ gives a contradiction. Hence, it must be that $x_m = x_p$. The constrained problem becomes:

$$\min_x (c_m + c_p)x + \Pi(x)$$

Straightforwardly, we have $x_m = x_p = [\Pi']^{-1}(-(c_m + c_p)) = z(c_m + c_p)$. □

Proofs of Propositions 2 and 4, and Corollary 1. Proposition 2 is simply a special case of Proposition 4. Thus, in this section, we prove the latter proposition.

The court's problem is to choose functions $x_m(c_m)$ and $x_p(c_p)$ to minimize the expected social loss:

$$W = \iint_{c_m,c_p} \left[\Pi\left(\min\{x_m(c_m), x_p(c_p)\}\right) + c_m x_m(c_m) + c_p x_p(c_p)\right] g_m(c_m) g_p(c_p) dc_m dc_p$$

Taking the derivative w.r.t. $x_i(c_i)$ gives:

$$\begin{aligned}\frac{\partial W}{\partial x_i(c_i)} &= c_i + \Pi'(x_i(c_i)) \int_{c_{-i}} \mathbf{1}[x_i(c_i) < x_{-i}(c_{-i})] g_{-i}(c_{-i}) dc_{-i} \\ &= c_i + \Pi'(x_i(c_i)) \Pr[x_{-i}(c_{-i}) > x_i(c_i)]\end{aligned}$$

First, we make a technical point about first order conditions (FOCs). The FOCs characterize the optimum wherever the first derivative is continuous (in x_i). Notice that this will be true whenever $\Pr(x_{-i}(c_i) > x_i)$ is also continuous. Since the distribution of c's is itself continuous, the probability function will be continuous except at values of x at which there is (partial)-pooling. Moreover, at these points of discontinuity, there may be a range of c_i's for which the first order condition cannot be satisfied (because $\frac{\partial W}{\partial x_i}(x) < 0$ but $\lim_{x' \uparrow x} \frac{\partial W}{\partial x_i}(x') > 0$). Naturally, for these c_i's, the planner does best to pool on x as well. But, since the first order condition is not met, changes in x will have first order effects on social welfare. Hence, we must additionally consider a joint deviation where both m and p types switch from x to some other pooling level x'. (When the first order condition holds exactly, this isn't necessary, since the benefits of any such deviation will be second order.)

We now begin the proof proper. The proof is in many steps. We proceed in the following order: (1) We show that the second-best schedules must be continuous and weakly decreasing; (2) we characterize the schedule whenever it is strictly decreasing; (3) we show that the schedule must be constant when c_i lies below some threshold $\hat{c}_i$; (4) we characterize that threshold as well as the pooling care level; (5) we show that the thresholds are unique; and (6) we show that the schedule must be decreasing beyond this threshold. Taken together, these steps prove the claims.

First, since the objective function is strictly concave, the optimizers must be singleton-valued. Furthermore, since the objective function is continuous, and the optimization is over a compact set, the optimizers $x_i(c_i)$ must themselves be continuous, by Berge's Theorem of the maximum. Moreover, the second-best functions $x_i(c_i)$ must be weakly decreasing in c_i. To see this, note that for any schedule $x_i(c_i)$ that is strictly increasing over some interval, we can construct an alternative schedule $y_i(c_i)$ that is strictly decreasing, and generates the same marginal distribution over care levels. The alternative schedule y_i produces the amount of care and the same likelihood of harms as x_i, but assigns the higher care levels to agents with lower costs. This clearly reduces the social loss.

Second, we show that whenever the second-best schedule is strictly decreasing, it is characterized by $x_i(c_i) = z\left(\frac{c_i}{G_{-i}(c_{-i}(c_i))}\right)$. To see this, note by the above logic that the first order conditions must be satisfied in this case. Thus, we have:

$$\Pi'(x_i(c_i))\,\Pr[x_{-i}(c_{-i}) > x_i(c_i)] = -c_i$$

Moreover, if $x_i(c_i)$ is decreasing in a neighborhood where care level x is chosen, then $x_{-i}(c_i)$ must also be decreasing in a corresponding neighborhood where that same care level is taken. (If not, the pooling by one side would cause pooling by the other side.) Hence, $x_i(c_i)$ and $x_{-i}(c_{-i})$ must both be locally invertible in this region. Let $c_{-i}(c_i) = x_{-i}^{-1}(x_i(c_i))$. Then, the first order condition becomes:

$$\begin{aligned}\Pi'(x_i(c_i))\,\Pr[c_{-i} < c_{-i}(c_i)] &= -c_i \\ x_i(c_i) &= [\Pi']^{-1}\left(-\frac{c_i}{G_{-i}(c_{-i}(c_i))}\right) = z\left(\frac{c_i}{G_{-i}(c_{-i}(c_i))}\right)\end{aligned}$$

Now, suppose $c_m = c_m(c_p)$. It follows that $c_p = c_p(c_m)$. Then, since z is strictly decreasing, and since $x_m(c_m) = x_p(c_p)$ (by construction):

$$z\left(\frac{c_m}{G_p(c_p(c_m))}\right) = z\left(\frac{c_p}{G_m(c_m(c_p))}\right)$$
$$\frac{c_m}{G_p(c_p(c_m))} = \frac{c_p}{G_m(c_m(c_p))}$$
$$c_m G_m(c_m) = c_p G_p(c_p)$$

This expression implicitly defines the functions $c_{-i}(c_i)$. Moreover, by the implicit function theorem:

$$\frac{\partial c_{-i}}{\partial c_i} = \frac{G_i(c_i) + c_i g_i(c_i)}{G_{-i}(c_{-i}(c_i)) + c_{-i}(c_i) g_{-i}(c_{-i}(c_i))}$$

We have an explicit characterization of the second-best schedule whenever it is strictly decreasing. We must confirm that this schedule is indeed strictly decreasing in costs. Since $z'(\cdot) < 0$, it suffices to show that $\frac{c_i}{G_{-i}(c_{-i}(c_i)}$ is a strictly increasing. Differentiating gives:

$$\frac{\partial}{\partial c_i}\left(\frac{c_i}{G_{-i}(c_{-i}(c_i))}\right) = \frac{1}{G_{-i}(c_{-i}) + c_{-i} g_{-i}(c_{-i})}\left[1 - \frac{c_i g_i(c_i)}{G_i(c_i)} \cdot \frac{c_{-i} g_{-i}(c_{-i})}{G_{-i}(c_{-i})}\right]$$

where we occasionally suppress the dependence of c_{-i} on c_i, and repeatedly use the fact that $c_i G_i(c_i) = c_{-i} G_{-i}(c_{-i})$. Hence, to have a decreasing second-best schedule, it suffices that $\frac{c_i g_i(c_i)}{G_i(c_i)} \cdot \frac{c_{-i} g_{-i}(c_{-i})}{G_{-i}(c_{-i})} < 1$ — a property that we establish, below.

Third, we show that there must exist $\hat{c}_m > \underline{c}_m$ and $\hat{c}_p > \underline{c}_p$ s.t. $x_m(c_m) = \hat{x} = x_p(c_p)$ for all $c_i < \hat{c}_i$. Suppose not. I.e. suppose there exists $\varepsilon > 0$ s.t. $x_p(c_p)$ is strictly decreasing on the interval $[\underline{c}_p, \underline{c}_p + \varepsilon]$. We know that neither agent-type will take a care level that they know (for sure) will be larger than their opponent's. Hence, since the x's are weakly decreasing, it must be that $x_m(\underline{c}_m) = \overline{x} = x_p(\underline{c}_p)$. Consider now types close to the lower bound. Since $x_p(c_p)$ is strictly decreasing on $[\underline{c}_p, \underline{c}_p + \varepsilon]$, it must be that $\Pr[x_p(c_p) > x_m]$ is continuous for $x_m \in [x_p(\underline{c}_p + \varepsilon), \overline{x})$. Hence, there exists $\delta(\varepsilon)$ s.t. $x_m(c_m)$ is characterized by the FOCs for $c_m \in [\underline{c}_m, \underline{c}_m + \delta]$. Hence, over this interval, $x_m(c_m) = z\left(\frac{c_m}{\Pr[x_p(c_p) > x_m(c_m)]}\right)$. But, $\lim_{x_m \uparrow \overline{x}} \Pr[x_p(c_p) \geq x_m] = 0$, and so $x_m(\underline{c}_m) = 0$ (by the Inada conditions). Hence $\overline{x} = 0$, and since $0 \leq x_i(c_i) \leq \overline{x}$ for each i, it must be that $x_i(c_i) = 0$ for all i. But this contradicts the assumption that x_p was strictly decreasing on the interval $[\underline{c}_p, \underline{c}_p + \varepsilon]$. Hence, it must be that both x_m and x_p are constant for $c_i \leq \hat{c}_i$.

Fourth, we characterize the pooling care level and the threshold defining the pool. Let $x_i(c_i) = \hat{x}$ for $c_i \leq \hat{c}_i$. By construction, there exists some $\varepsilon > 0$ s.t. $x_i(c_i)$ is strictly decreasing on the interval $(\hat{c}_i, \hat{c}_i + \varepsilon)$. Hence, on this interval, the care levels are characterized by the FOCs. Moreover, since $x_i(c_i)$ is continuous, it must be that the FOC is satisfied at $\hat{c}_i$ (for each i). It follows that:

$$z\left(\frac{\hat{c}_m}{G_p(\hat{c}_p)}\right) = \hat{x} = z\left(\frac{\hat{c}_p}{G_m(\hat{c}_m)}\right)$$

which implies that $\hat{c}_m G_m(\hat{c}_m) = \hat{c}_p G_p(\hat{c}_p)$. Hence, the thresholds satisfy $\hat{c}_m = c_m(\hat{c}_p)$.

Now, noting that $\hat{x}$ implicitly pins down $\hat{c}_m$ and $\hat{c}_p$, $\hat{x}$ is chosen to minimize the social loss:

$$\begin{aligned}W(\hat{x}) = &\int_{\underline{c}_m}^{\hat{c}_m(\hat{x})} \hat{x} c_m g_m(c_p) dc_m + \int_{\underline{c}_p}^{\hat{c}_p(\hat{x})} \hat{x} c_p g_p(c_p) dc_p + G_m(\hat{c}_m) G_p(\hat{c}_p) \Pi(\hat{x}) + \\ &+ \int_{\hat{c}_m(\hat{x})}^{\bar{c}_m} x_m(c_m) c_m g_m(c_P) dc_m + \int_{\hat{c}_p(\hat{x})}^{\bar{c}_p} x_p(c_p) c_p g_p(c_p) dc_p + \\ &+ \int_{\hat{c}_m(\hat{x})}^{\bar{c}_m} G_p(c_p(c_m)) \Pi(x_m(c_m)) g_m(c_m) dc_m + \int_{\hat{c}_p(\hat{x})}^{\bar{c}_p} G_m(c_m(c_p)) \Pi(x_p(c_p)) g_p(c_p) dc_p\end{aligned}$$

Taking the first order condition, and noting that all indirect effects through $\hat{c}_m$ and $\hat{c}_p$ cancel, we have:

$$\begin{gathered}G_m(\hat{c}_m) E[c_m \,|\, c_m < \hat{c}_m] + G_p(\hat{c}_p) E[c_p \,|\, c_p < \hat{c}_p] = -G_m(\hat{c}_m) G_p(\hat{c}_p) \Pi'(\hat{x}) \\ \frac{E[c_m \,|\, c_m < \hat{c}_m]}{\hat{c}_m} + \frac{E[c_p \,|\, c_p < \hat{c}_p]}{\hat{c}_p} = 1\end{gathered}$$

where we use the fact that $\hat{c}_m G_m(\hat{c}_m) = \hat{c}_p G_p(\hat{c}_p)$ and that $\Pi'(\hat{x}) = -\frac{\hat{c}_p}{G_m(\hat{c}_m)}$. Thus, we have the conditions that characterize the thresholds $\hat{c}_m$ and $\hat{c}_p$, and the pooling level $\hat{x}$.

Fifth, we must show that the thresholds are unique. As a preliminary step, note that:

$$\frac{\partial}{\partial c_i}\left(\frac{E[c_i \,|\, c_i < \hat{c}_i]}{\hat{c}_i}\right) = \frac{1}{\hat{c}_i}\left[\frac{\hat{c}_i g_i(\hat{c}_i)}{G_i(\hat{c}_i)} - \left(1 + \frac{\hat{c}_i g_i(\hat{c}_i)}{G_i(\hat{c}_i)}\right)\frac{E[c_i \,|\, c_i < \hat{c}_i]}{\hat{c}_i}\right]$$

Recall also that:

$$\frac{\partial c_p(c_m)}{\partial c_m} = \frac{G_m(c_m)}{G_p(c_p(c_m))} \cdot \frac{1 + \frac{c_m g_m(c_m)}{G_m(c_m)}}{1 + \frac{c_p(c_m) g_p(c_p(c_m))}{G_p(c_p(c_m))}}$$

Now, define:

$$\phi(\tilde{c}_m) = \frac{E[c_m \,|\, c_m < \tilde{c}_m]}{\tilde{c}_m} + \frac{E[c_p \,|\, c_p < c_p(\tilde{c}_m)]}{c_p(\tilde{c}_m)} - 1$$

We know that $\phi(\hat{c}_m) = 0$. To prove uniqueness, it suffices to show that $\phi(\cdot)$ has a unique root. Notice that $\phi(\underline{c}_m) = \frac{\underline{c}_m}{\underline{c}_m} + \frac{\underline{c}_p}{\underline{c}_p} - 1 = 1 > 0$, which makes use of the fact that $c_p(\underline{c}_m) = \underline{c}_p$. Also, $\lim_{\tilde{c}_m \to \infty} \phi(\tilde{c}_m) = -1$. Then, since ϕ is a continuous function, there must be at least one $\tilde{c}_m \in (\underline{c}_m, \infty)$ s.t. $\phi(\tilde{c}_m) = 0$. Let $\hat{c}_m$ be the first such instance. Since $\phi(\tilde{c}_m) > 0$ for $\tilde{c}_m < \hat{c}_m$, we must have that $\phi'(\hat{c}_m) < 0$.

In what follows, we write $\tilde{c}_p = c_p(\tilde{c}_m)$ and we suppress this dependence in the notation for convenience. Now:

$$\begin{aligned}
\phi'(\tilde{c}_m) &= \frac{1}{\tilde{c}_m}\left[\frac{\tilde{c}_m g_m(\tilde{c}_m)}{G_m(\tilde{c}_m)} - \left(1 + \frac{\tilde{c}_m g_m(\tilde{c}_m)}{G_m(\tilde{c}_m)}\right)\frac{E[c_m \,|\, c_m < \tilde{c}_m]}{\hat{c}_m}\right] \\
&\quad + \frac{1}{\tilde{c}_p}\left[\frac{\tilde{c}_p g_p(\tilde{c}_p)}{G_p(\tilde{c}_p)} - \left(1 + \frac{\tilde{c}_p g_p(\tilde{c}_p)}{G_p(\tilde{c}_p)}\right)\frac{E[c_p \,|\, c_p < \tilde{c}_p]}{\hat{c}_p}\right]\left(\frac{G_m(\tilde{c}_m)}{G_p(\tilde{c}_p)} \cdot \frac{1 + \frac{\tilde{c}_m g_m(\tilde{c}_m)}{G_m(\tilde{c}_m)}}{1 + \frac{\tilde{c}_p g_p(\tilde{c}_p)}{G_p(\tilde{c}_p)}}\right) \\
&= \frac{1}{\tilde{c}_m}\left[\frac{\tilde{c}_m g_m(\tilde{c}_m)}{G_m(\tilde{c}_m)} + \left(1 + \frac{\tilde{c}_m g_m(\tilde{c}_m)}{G_m(\tilde{c}_m)}\right)\left\{\frac{\frac{\tilde{c}_p g_p(\tilde{c}_p)}{G_p(\tilde{c}_p)}}{1 + \frac{\tilde{c}_p g_p(\tilde{c}_p)}{G_p(\tilde{c}_p)}} - \left(\frac{E[c_m \,|\, c_m < \tilde{c}_m]}{\hat{c}_m} + \frac{E[c_p \,|\, c_p < \tilde{c}_p]}{\hat{c}_p}\right)\right\}\right]
\end{aligned}$$

where we use the fact that $\tilde{c}_m = \tilde{c}_p \cdot \frac{G_p(\tilde{c}_p)}{G_m(\tilde{c}_m)}$. Evaluating this at $\tilde{c}_m = \hat{c}_m$ gives:

$$\begin{aligned}
\phi'(\hat{c}_m) &= \frac{1}{\hat{c}_m}\left[\frac{\hat{c}_m g_m(\hat{c}_m)}{G_m(\hat{c}_m)} + \left(1 + \frac{\hat{c}_m g_m(\hat{c}_m)}{G_m(\hat{c}_m)}\right)\left\{\frac{\frac{\hat{c}_p g_p(\hat{c}_p)}{G_p(\hat{c}_p)}}{1 + \frac{\hat{c}_p g_p(\hat{c}_p)}{G_p(\hat{c}_p)}} - 1\right\}\right] \\
&= \frac{1}{\hat{c}_m}\left[\frac{\hat{c}_p g_p(\hat{c}_p)}{G_p(\hat{c}_p)} \frac{1 + \frac{\hat{c}_m g_m(\hat{c}_m)}{G_m(\hat{c}_m)}}{1 + \frac{\hat{c}_p g_p(\hat{c}_p)}{G_p(\hat{c}_p)}} - 1\right] \\
&= \frac{1}{\hat{c}_m} \cdot \frac{1}{1 + \frac{\hat{c}_p g_p(\hat{c}_p)}{G_p(\hat{c}_p)}}\left[\frac{\hat{c}_m g_m(\hat{c}_m)}{G_m(\hat{c}_m)} \cdot \frac{\hat{c}_p g_p(\hat{c}_p)}{G_p(\hat{c}_p)} - 1\right]
\end{aligned}$$

Since, $\phi'(\hat{c}_m) < 0$, it follows that $\frac{\hat{c}_m g_m(\hat{c}_m)}{G_m(\hat{c}_m)} \cdot \frac{\hat{c}_p g_p(\hat{c}_p)}{G_p(\hat{c}_p)} < 1$. By the argument above, this ensures that $x_i(c_i)$ is strictly decreasing for c_i slightly above $\hat{c}_i$.

We need to show that $\hat{c}_m$ is the unique root of ϕ. Suppose not. Let $c_m^\dagger > \hat{c}_m$ denote the next smallest root. Then $\phi(c_m^\dagger)$. Moreover, since ϕ is continuous and $\phi(c_m) < 0$ for $c_m \in (\hat{c}_m, c_m^\dagger)$, it must be that $\phi'(c_m^\dagger) > 0$. Hence, by the previous argument: $\frac{c_m^\dagger g_m(c_m^\dagger)}{G_m(c_m^\dagger)} \cdot \frac{c_p^\dagger g_p(c_p^\dagger)}{G_p(c_p^\dagger)} > 1$, where $c_p^\dagger = c_p(c_m^\dagger)$. But this violates the decreasing generalized reverse hazard rate property, since if $\frac{\hat{c}_m g_m(\hat{c}_m)}{G_m(\hat{c}_m)} \cdot \frac{\hat{c}_p g_p(\hat{c}_p)}{G_p(\hat{c}_p)} < 1$, it must be that $\frac{c_m g_m(c_m)}{G_m(c_m)} \cdot \frac{c_p g_p(c_p)}{G_p(c_p)} < 1$ for all pairs (c_m, c_p) s.t. $c_m > \hat{c}_m$ and $c_p > \hat{c}$.

Sixth, we must show that $x_i(c_i)$ is strictly decreasing for all $c_i > \hat{c}_i$. One way to see this is to note that since $\frac{c_m g_m(c_m)}{G_m(c_m)} \cdot \frac{c_p(c_m) g_p(c_p(c_m))}{G_p(c_p(c_m))} < 1$ for all $c_m > \hat{c}_m$, that $x_m(c_m)$ is strictly decreasing $c_m > \hat{c}_m$, and likewise for c_p. (This follows from part two of the proof.)

But more strongly, assume the opposite and suppose there is an interval $[c_i', c_i'']$ with $c_i' > \hat{c}_i$, s.t. $x_i(c_i)$ is constant on $(c_i', c_i'']$. Then, it must be that the x_i chosen on this interval is optimal for the average cost type in the pool (similar to how $\hat{x}$ was computed above). Given that $\frac{c_m g_m(c_m)}{G_m(c_m)} \cdot \frac{c_p(c_m) g_p(c_p(c_m))}{G_p(c_p(c_m))} < 1$, every type in the interval, if separating themselves, would want to produce less than $x(c_i')$, and so on average, the pool must produce strictly less than $x(c_i')$. But then, necessarily, there will be a discontinuity in x_i at c_i', which cannot be. Hence, $x_i(c_i)$ is strictly decreasing for $c_i > \hat{c}_i$. This completes the proof. □

Proof of Lemma 1. First, we show that $\hat{c} \geq \bar{c}$ if $\bar{c} \leq 2E[c]$. To see this, recall that that $\hat{c} = 2E[c \,|\, c < \hat{c}]$. Suppose $\hat{c} \geq \bar{c}$. Then $E[c \,|\, c < \hat{c}] = E[c]$, and so $\hat{c} = 2E[c]$. Consistency requires that $2E[c] \geq \bar{c}$, as required.

Next, we verify the comparative statics. Consider two distributions of costs, $G(c)$ and $H(c)$, and let $\hat{c}_i$ satisfy $\hat{c}_i = 2E_i[c \,|\, c < \hat{c}_i]$ for $i \in \{G, H\}$. Begin with scaling — i.e. suppose $c_H = \kappa c_G$. Then $\kappa \hat{c}_G = 2E[\kappa c_G \,|\, \kappa_1 c_G < \kappa \hat{c}_G] = 2E[c_H \,|\, c_H < \kappa \hat{c}_G]$, and so $\hat{c}_H = \kappa \hat{c}_G$. Moreover, since $H(\kappa c) = G(c)$ for all c, we have: $H(\hat{c}_H) = H(\kappa \hat{c}_G) = G(\hat{c}_G)$.

Finally, suppose H is a mean preserving spread of G. Then, by the Rothschild and Stiglitz (1970) condition, $\int^c H(t)dt \geq \int^c G(t)dt$ for all t. This implies that:

$$
\begin{aligned}
\frac{\int^{\hat{c}_G} H(c)dc}{G(\hat{c}_G)} &\geq \frac{\int^{\hat{c}_G} G(c)dc}{G(\hat{c}_G)} \\
\frac{\int^{\hat{c}_G} H(c)dc}{H(\hat{c}_G)} &> \frac{\int^{\hat{c}_G} G(c)dc}{G(\hat{c}_G)} \\
\hat{c}_G - \frac{\int^{\hat{c}_G} H(c)dc}{H(\hat{c}_G)} &< \hat{c}_G - \frac{\int^{\hat{c}_G} G(c)dc}{G(\hat{c}_G)} \\
E_H[c \,|\, c < \hat{c}_G] &< E_G[c \,|\, c < \hat{c}_G]
\end{aligned}
$$

where the second inequality uses the fact that $H(\hat{c}_G) < G(\hat{c}_G)$. The fourth line uses the property that, for any function f with $f(a) = 0$, $\int_a^c x f(x)dx = c - \int_a^c F(x)dx$, where $F'(x) = f(x)$. Then, by expression (3) observe that $\frac{E_G[c \,|\, c < \hat{c}_G]}{\hat{c}_G} = \frac{1}{2} > \frac{E_H[c \,|\, c < \hat{c}_G]}{\hat{c}_G}$.

Also, by expression (3), $\frac{E_H[c \,|\, c < \hat{c}_H]}{\hat{c}_H} = \frac{1}{2}$, and since $\frac{E_H[c \,|\, c < \alpha]}{\alpha}$ is a decreasing function of α (which follows from the fact that the CDFs are sufficiently log-concave), it must be that $\hat{c}_H < \hat{c}_G$. Moreover, this implies that $H(\hat{c}_H) < H(\hat{c}_G) < G(\hat{c}_G)$. □

Proof of Proposition 3 and Corollary 3. Let $x(c;\lambda)$ denote the second-best schedule. (We will often omit the 2nd argument, for notational convenience.) We first show that there must be pooling for $\lambda > 0$ sufficiently small. Suppose not, i.e. suppose the second-best schedule $x(c)$ is purely separating, so that $x'(c) < 0$. Take agent i, and note by symmetry that $x_i(c_i) > x_{-i}(c_{-i})$ whenever $c_i < c_{-i}$. Since $x(c)$ satisfies the first order conditions, we have for agent i:

$$\frac{\partial W}{\partial x(c_i)} = c_i + (1-\lambda)\int_{\underline{c}}^{c_i} \Pi'(\lambda x(c_{-i}) + (1-\lambda)x(c_i))g(c_{-i})dc_{-i} + \lambda\int_{c_i}^{\overline{c}} \Pi'(\lambda x(c_i) + (1-\lambda)x(c_{-i}))g(c_{-i})dc_{-i} \tag{4}$$

Then, for $c_i = \underline{c}$, this reduces to:

$$\frac{\partial W}{\partial x(\underline{c})} = \underline{c} + \lambda\int_{\underline{c}}^{\overline{c}} \Pi'(\lambda x(\underline{c}) + (1-\lambda)x(c_{-i}))g(c_{-i})dc_{-i}$$

Since $\Pi'' > 0$, then $\Pi'(\lambda x(c_i) + (1-\lambda)x(c_{-i})) > \Pi'((1-\lambda)x(c_{-i}))$ whenever $x(\underline{c}) > 0$. Hence:

$$\frac{\partial W}{\partial x(\underline{c})} > \underline{c} + \lambda\int_{\underline{c}}^{\overline{c}} \Pi'((1-\lambda)x(c_{-i}))g(c_{-i})dc_{-i}$$

Then, since $\underline{c} > 0$ and $\int_{\underline{c}}^{\overline{c}} \Pi'((1-\lambda)x(c_{-i}))g(c_{-i})dc_{-i} < 0$ is finite, there exists $\lambda' > 0$ s.t. $\frac{\partial W}{\partial x(\underline{c})} > 0$ for all choices of $x(\underline{c})$ whenever $\lambda < \lambda'$. It follows that $x(\underline{c}) = 0$. But, then since $x(c)$ is weakly decreasing, this implies that $x(c) = 0$ for all c, which cannot be. Hence, there must be some pooling of low-cost types.

Define $\chi(c_i, c_{-i};\lambda) = z^{-1}\left(\lambda x(\max\{c_i, c_{-i}\}) + (1-\lambda)x(\min\{c_i, c_{-i}\})\right)$. When a type c_i and type c_{-i} agent interact, the resulting 2nd best average care level coincides with the unilateral optimal care level for an agent with cost $\chi(c_i, c_{-i};\lambda)$. So, $z^-1(\cdot)$ maps care into costs. By construction, $x(c;\lambda) = z(\chi(c, c;\lambda))$, so to characterize the second-best schedule, it suffices to characterize the function χ.

Recall, from the unilateral problem, that $z^{-1}(x) = -\Pi'(x)$. Now, for any agent in the separating region (i.e. $c_i \geq \hat{c}(\lambda)$), we know that $x(c_i)$ is characterized by the FOC:

$$\begin{aligned}\frac{\partial W}{\partial x(c_i)} &= c_i + (1-\lambda)\int_{\underline{c}}^{c_i} \Pi'(\lambda x(c_{-i}) + (1-\lambda)x(c_i))g(c_{-i})dc_{-i} + \lambda\int_{c_i}^{\overline{c}} \Pi'(\lambda x(c_i) + (1-\lambda)x(c_{-i}))g(c_{-i})dc_{-i} = 0 \\ &= c_i - (1-\lambda)\int_{\underline{c}}^{c_i} \chi(c_i, c_{-i};\lambda)g(c_{-i})dc_{-i} - \lambda\int_{c_i}^{\overline{c}} \chi(c_i, c_{-i};\lambda)g(c_{-i})dc_{-i} = 0 \qquad (5)\end{aligned}$$

Notice that (5) defines a system of equations (one for each c_i) that characterizes the function

χ directly in terms of c's and λ. Moreover, in the case of $\hat{c}(\lambda)$ we have:

$$(1-\lambda)G(\hat{c}(\lambda))\underbrace{\chi(\hat{c}(\lambda), c(\hat{\lambda}); \lambda)}_{=\chi(\hat{c}(\lambda))} + \lambda\int_{\hat{c}(\lambda)}^{\overline{c}} \chi(\hat{c}(\lambda), c; \lambda)g(c)dc = \hat{c} \tag{6}$$

Now, consider the optimal pooling standard. This standard must minimize the social loss amongst members of the pool, subject to the constraint that the threshold type is kept indifferent between pooling and separating. The pooling loss is:

$$2\hat{x}\int_{\underline{c}}^{\hat{c}} cg(c)dc + G(\hat{c})^2\Pi(\hat{x}) + 2G(\hat{c})\int_{\hat{c}}^{\infty} \Pi(\lambda\hat{x} + (1-\lambda)x(c))g(c)dc$$

where the final term reflects the probability that an agent in the pool is matched with an agent without. Taking the first order condition w.r.t $\hat{x}$ gives:

$$2E[c\,|\,c<\hat{c}] + G(\hat{c})\Pi'(\hat{x}) + 2\lambda\int_{\hat{c}}^{\infty} \Pi'(\lambda\hat{x} + (1-\lambda)x(c))g(c)dc = 0 \tag{7}$$

$$2E[c\,|\,c<\hat{c}] - G(\hat{c})\chi(\hat{c}) - 2\lambda\int_{\hat{c}}^{\overline{c}} \chi(\hat{c}(\lambda), c; \lambda)g(c)dc = 0 \tag{8}$$

Combining (6) and (8) gives:

$$\left(\frac{1}{2} - \lambda\right)G(\hat{c})\chi(\hat{c}(\lambda)) + E[c\,|\,c<\hat{c}(\lambda)] = \hat{c}(\lambda) \tag{9}$$

which implictly characterizes $\hat{c}(\lambda)$. Notice that this characterization is independent of Π, which proves the claim in Corollary 3.

The characterization is particularly straightforward in the cases of $\lambda = 0$ and $\lambda = \frac{1}{2}$. When $\lambda = 0$, we know that $\chi(\hat{c}(0)) = \frac{\hat{c}}{G(\hat{c})}$, and so (9) reduces to $\hat{c}(0) = 2E[c\,|\,c<\hat{c}(0)]$. When $\lambda = \frac{1}{2}$, (9) simplifies to $\hat{c}\left(\frac{1}{2}\right) = E[c\,|\,c<\hat{c}\left(\frac{1}{2}\right)]$, which can only be true if $\hat{c}\left(\frac{1}{2}\right) = \underline{c}$.

Finally, note that $\frac{\hat{c}-E[c\,|\,c<\hat{c}]}{G(\hat{c})}$ is increasing in $\hat{c}$. Then, since (9) can be written: $1-2\lambda = \frac{\hat{c}-E[c\,|\,c<\hat{c}]}{G(\hat{c})\chi(\hat{c})}$, and since the left-hand side term is decreasing in λ, $\hat{c}(\lambda)$ must be decreasing in λ. □

Proof of Corollary 2. Suppose $\hat{c} \geq \overline{c}$. This implies that $G(\hat{c}) = 1$, and $E[c\,|\,c<\hat{c}] = E[c]$. Now, By equation (7) in the Proof of Proposition 3, the optimal pooling standard satisfies

$\Pi'(\hat{x}) = -2E[c]$, which implies $\hat{x} = z(2E[c])$. Substituting this into equation (9) gives:

$$\hat{c} = E[c] - \frac{1-2\lambda}{2}(-2E[c]) = 2(1-\lambda)E[c]$$

Then, since $\hat{c} \geq \bar{c}$, it must be that $2(1-\lambda)E[c] \geq \bar{c}$, which implies that $\lambda \leq 1 - \frac{\bar{c}}{2E[c]}$. □

Proof of Proposition 5. The proof is the same as in Shavell (1987). Since the two rules differ only in which agent is the residual bearer of harms, the proof will follow the same structure in both cases. Thus, without loss of generality, consider a negligence rule and suppose the motorist is the defendant.

Assuming that each type of pedestrian takes care at the second best level appropriate to their cost, a motorist with cost c_m's expected cost from taking care x_m is:

$$U_m(x_m) = \begin{cases} c_m x_m & \text{if } x_m \geq x_m^{2nd}(c_m) \\ c_m x_m + \int_{\underline{c}_p}^{\bar{c}_p} \Pi\left(\min\left\{x_m, x_p^{2nd}(c_p)\right\}\right) g_p(c_p) dc_p & \text{if } x_m < x_m^{2nd}(c_m) \end{cases}$$

Now, since $x_m^{2nd}(c_m)$ is socially efficient, it follows that:

$$c_m x_m + \int_{\underline{c}_p}^{\bar{c}_p} \left[c_p x_p^{2nd}(c_p) + \Pi\left(\min\left\{x_m, x_p^{2nd}(c_p)\right\}\right)\right] g_p(c_p) dc_p$$

is minimized at $x_m = x_m^{2nd}(c)$. Thus, for any $x_m < x_m^{2nd}$:

$$\begin{aligned} U_m(x_m) &= c_m x_m + \int_{\underline{c}_p}^{\bar{c}_p} \Pi\left(\min\left\{x_m, x_p^{2nd}(c_p)\right\}\right) g_p(c_p) dc_p \\ &\geq c_m x_m^{2nd}(c_m) + \int_{\underline{c}_p}^{\bar{c}_p} \Pi\left(\min\left\{x_m^{2nd}(c_m), x_p^{2nd}(c_p)\right\}\right) g_p(c_p) dc_p \\ &> c_m x_m^{2nd}(c_m) \end{aligned}$$

Hence, the motorist would never choose $x_m < x_m^{2nd}(c_m)$. Straight-forwardly, the motorist never has an incentive to choose $x_m > x_m^{2nd}(c_m)$ since expected costs are increasing in this region. Hence, the motorist does best to choose the second best care level $x_m^{2nd}(c_m)$.

Now, consider the pedestrian's optimal choice, assuming that the motorist takes due care. Then the pedestrian will be the residual bearer of harms. Her expected cost from taking care x_p is:

$$U_p(x_p) = c_p x_p + \int_{\underline{c}_m}^{\bar{c}_m} \Pi\left(\min\{x_m(c_m), x_p\}\right) g_m(c_m) dc_m$$

Then, using the same argument, the pedestrian's effective cost is minimized by choosing $x_p = x_p^{2nd}(c_p)$. □

Appendices

A Worked Example

The following example illustrates the key ideas discussed in Section 3, stemming from Proposition 2

Example 1. Suppose the costs are distributed according to a triangle distribution with a mode at $\underline{c}$, so that $g(c) = 2\left(\frac{\overline{c}-c}{\overline{c}-\underline{c}}\right)$. Then, the conditional expectation is:

$$E[c\,|\,c<\hat{c}] = \begin{cases} \frac{\overline{c}(\hat{c}+\underline{c})-\frac{2}{3}\left(\hat{c}^2+\underline{c}\hat{c}+\underline{c}^2\right)}{2\left(\overline{c}-\frac{\hat{c}+\underline{c}}{2}\right)} & \text{if } \hat{c}<\overline{c} \\ \frac{2}{3}\underline{c}+\frac{1}{3}\overline{c} & \text{if } \hat{c}>\overline{c} \end{cases}$$

.

The fixed point of expression (3) is:

$$\hat{c} = \begin{cases} \frac{\sqrt{24\overline{c}\underline{c}-15\underline{c}^2}-\underline{c}}{2} & \text{if } \overline{c}>4\underline{c} \\ \frac{4}{3}\underline{c}+\frac{2}{3}\overline{c} & \text{if } \overline{c}<4\underline{c} \end{cases}$$

There is a pure reasonable person standard whenever $\overline{c} < 4\underline{c}$ — i.e. whenever the tail of the distribution is relatively short. Otherwise, there is a reasonable person standard coupled with excuses.

B Generalized OWA Technology

In our main analysis, we used the ordered weighted average technology to aggregate the agents' individual care choices into an average care level. We chose this technology for its simplicity — it is piece-wise linear in x_m and x_p. In this sub-section, we briefly demonstrate that the results can easily accommodate a more general order weighted technology.

Let $\phi(x)$ be a continuous function satisfying either $\phi' > 0$ and $\phi'' < 0$, or $\phi' < 0$ and $\phi'' > 0$. Define the average function:

$$\alpha(x_m, x_p; \lambda) = \phi^{-1}\left[\lambda\phi(\max\{x_m, x_p\}) + (1-\lambda)\phi(\min\{x_m, x_p\})\right]$$

where $\lambda \in [0, 0.5]$. The function α so defined returns an order weighted generalized average of x_m and x_p. Notice that, regardless of the choice of ϕ, $\alpha = \min\{x_m, x_p\}$ whenever $\lambda = 0$. Hence, all of the insights of our baseline analysis (under perfect complements) will continue to hold in this generalized setting.

Moreover, the insights will continue to hold even when the care technology is characterized by moderate complements. To see this, given the discussion in subsection 2.B., it suffices to show that when $\lambda > 0$ is small, the first best schedule continues to coordinate both agents on the same care level, even if their costs differ. Indeed, the following Lemma shows that the 'coordination regime' of the first best schedule remains unchanged if we replace the simple order weighted average with a generalized order weighted technology.

Lemma 2. *For any generalized order weighted average technology satisfying the conditions above, the first best schedule satisfies:*

$$x_m^{1st}(c_m, c_p) = x_p^{1st}(c_m, c_p) = z(c_m + c_p)$$

whenever $\lambda < \frac{\min\{c_m, c_p\}}{c_m + c_p}$.

The first best schedule will behave somewhat differently in the 'tailoring regime', where it may no longer be optimal to assign the entirety of care to the least cost avoider. Indeed, by convexifying the first best schedules in this regime will be more continuous, and have less of a 'bang-bang' flavor.

In section 1, we contrasted the OWA technology with the more familiar CES technology, both of which facilitate a parameterization of the degree of substitutability between the agents' care decisions. By setting $\phi(x) = x^\rho$, we can combine these approaches by defining the order weighted CES aggregator:

$$\alpha(x_m, x_p; \lambda, \rho) = [\lambda(\max\{x_m, x_p\})^\rho + (1 - \lambda)(\min\{x_m, x_p\})^\rho]^{\frac{1}{\rho}}$$

Proof Of Lemma 2. The logic mirrors the proof of Proposition 1. For concreteness, suppose $\phi' > 0$ and $\phi'' < 0$. Suppose $c_m < c_p$. Then it must be that $x_m \geq x_p$.

Suppose $x_m > x_p$. The planner's problem is:

$$W = \min_{x_m, x_p} c_m x_m + c_p x_p + \Pi(\phi^{-1}(\lambda\phi(x_m) + (1 - \lambda)\phi(x_p)))$$

The first order conditions are:

$$\frac{\partial W}{\partial x_m} = c_m + \frac{\Pi'(a(x_m, x_p; \lambda))}{\phi'(a(x_m, x_p; \lambda))}\lambda\phi'(x_m) = 0$$
$$\frac{\partial W}{\partial x_p} = c_p + \frac{\Pi'(a(x_m, x_p; \lambda))}{\phi'(a(x_m, x_p; \lambda))}(1-\lambda)\phi'(x_p) = 0$$

where $a(x_m, x_p; \lambda) = \phi^{-1}(\lambda\phi(x_m) + (1-\lambda)\phi(x_p))$. Since $x_m > 0$, we know that $\frac{c_m}{\lambda\phi'(x_m)} = -\frac{\Pi'(a(x_m,x_p;\lambda))}{\phi'(a(x_m,x_p;\lambda))}$. Moreover, since $\frac{\partial W}{\partial x_p} \geq 0$, we know that: $\frac{c_p}{(1-\lambda)\phi'(x_m)} \geq -\frac{\Pi'(a(x_m,x_p;\lambda))}{\phi'(a(x_m,x_p;\lambda))}$. Hence:

$$\frac{c_m}{\lambda\phi'(x_m)} \leq \frac{c_p}{(1-\lambda)\phi'(x_p)}$$
$$\frac{1-\lambda}{\lambda} \cdot \frac{c_m}{c_p} \leq \frac{\phi'(x_p)}{\phi'(x_m)}$$

Then, since $\phi'' < 0$ and $x_m > x_p$, it must be that $\frac{\phi'(x_p)}{\phi'(x_m)} < 1$, and so:

$$\frac{1-\lambda}{\lambda} \cdot \frac{c_m}{c_p} < 1$$
$$\lambda > \frac{c_m}{c_m + c_p}$$

Notice that this condition is independent of ϕ. Then, taking the contra-positive, whenever $\lambda \leq \frac{\min\{c_m,c_p\}}{c_m+c_p}$, it must be that $x_m = x_p$. If so, the planner's problem becomes:

$$\min_x (c_m + c_p)x + \Pi(x)$$

whose solution is very clearly $x_m = x_p = z(c_m + c_p)$. □

C A Model of Contracts

In this section, we briefly show how the model can be adapted to capture interactions in a contracts setting. As we will show, but for some (intuitive) modifications, the results from our main analysis carry over exactly.

Consider an interaction between a buyer B and a seller S. The buyer and seller may each invest effort $x_i \geq 0$ to facilitate the creation of a surplus. Effort is costly, and the unit cost of effort is c_i for agent $i \in \{B, S\}$. The value of the surplus depends on a measure of the 'average' effort exerted, and the intrinsic value of the item being transacted to the buyer. Formally, the surplus is $v_B \Pi(a(x_B, x_S))$, where $\Pi' > 0$ and $\Pi'' < 0$, so that effort increases the size of the surplus, but with diminishing returns. As usual, we construct the average effort using the order weighted average technology: $a(x_B, x_S) = \lambda \max\{x_B, x_S\} + (1-\lambda)\min\{x_B, x_S\}$, where $\lambda \in \left[0, \frac{1}{2}\right]$. We will focus on the case of perfect complements ($\lambda = 0$).

We assume that the buyer's valuation v_B and the seller's cost c_S are private information. For simplicity, we assume that the buyer's cost c_B is commonly known. v_B and c_S are each (independent) draws from continuous distributions with CDFs $G_B(v_B)$ and $G_S(c_S)$ that are sufficiently log-concave. The supports of the distributions are $[\underline{v}_B, \overline{v}_B]$ and $[\underline{c}_S, \overline{c}_S]$ (respectively), with $\underline{c}_S > 0$ and $\overline{v}_B < \infty$.

C.A. The first-best

First, let us characterize the first-best effort levels $x_B(v_B, c_S)$ and $x_S(v_B, c_S)$, which are the solutions to:

$$\max_{x_B, x_S} v_B \Pi(\min\{x_B, x_S\}) - c_B x_B - c_S x_S$$

Straightforwardly applying first order conditions, we find that the efficient investments are:

$$x_i(v_B, c_S)^{1st} = [\Pi']^{-1}\left(\frac{c_B + c_S}{v_B}\right) = z\left(\frac{c_B + c_S}{v_B}\right)$$

where $z(a) = [\Pi']^{-1}(a)$. This is analogous to the first-best expression in our baseline model, except that each agent's costs are normalized by the marginal benefit parameter v_B. We can easily verify that $z'(a) < 0$, so the first-best schedule is decreasing in each agent's costs, and increasing in the buyer's valuation.

C.B. The second-best

Now, consider the second-best setting, where the planner can condition each agent's investment decision on their own type (which is private information), but not on the opponent's type. The second-best effort levels $x_B(v_B)$ and $x_S(c_S)$ are the solutions to:

$$\max_{x_B(v_B), x_S(c_S)} \iint \{v_B \Pi(\min\{x_B, x_S\}) - c_B x_B - c_S x_S\}\, g_B(v_B) g_S(c_S) dv_B dc_S$$

Let $v_B(c_S)$ and $c_S(v_B)$ be functions that are implicitly defined by:

$$\frac{c_B}{v_B}E[v \mid v > v_B](1 - G_B(v_B)) = c_S G_S(c_S)$$

This expression is the analogue of the expression $c_m G_m(c_m) = c_p G_p(c_p)$ that we defined in Section ??. It will turn out that a seller with cost c_S will make the same investment as a buyer with valuation $v_B(c_S)$. Similarly, a buyer with valuation v_B will make the same investment as a seller with cost $c_S(v_B)$. Naturally, $v_B(c_S)$ and $c_S(v_B)$ are inverse functions of one another. We can verify, via the implicit function theorem, that $v'_B(c_S) < 0$, and similarly that $c'_S(v_B) < 0$. A seller with a higher cost will make the same investment as a buyer with a lower valuation, and vice versa.

The second-best effort schedules are characterized as follows:

Proposition 6. *There exist threshold $\hat{v}_B < \overline{v}_B$ and $\hat{c}_S > \underline{c}_S$ uniquely defined by:*

1. $\hat{v}_B = v_B(\hat{c}_S)$ *(or equivalently, $\hat{c}_S = c_S(\hat{v}_B)$), and*
2. $\frac{E[c_S \mid c_S < \hat{c}_S]}{\hat{c}_S} + \frac{\hat{v}_B}{E[v_B \mid v_B < \hat{v}_B]} = 1$

such that the second-best investment schedules are:

$$x_B^{2nd}(v_B) = \begin{cases} \hat{x} & \text{if } v_B > \hat{v}_B \\ z\left(\frac{c_B}{v_B G_S(c_S(v_B))}\right) & \text{if } v_B \leq \hat{v}_B \end{cases}$$

$$x_S^{2nd}(c_S) = \begin{cases} \hat{x} & \text{if } c_S < \hat{c}_S \\ z\left(\frac{c_S}{E[v_B \mid v_B > v_B(c_S)](1 - G_B(v_B(c_S)))}\right) & \text{if } c_S \geq \hat{c}_S \end{cases}$$

where $\hat{x} = z\left(\frac{\frac{c_B}{G_S(\hat{c}_S)} + \frac{E[c_S \mid c_S < \hat{c}_S]}{1 - G_B(\hat{v}_B)}}{E[v_B \mid v_B > \hat{v}_B]}\right)$.

Proposition 6 is analogous to Proposition 4. (Since the proof strategy is identical to the proof of Proposition 4, we do not replicate it here.) Similar to our main model, there is pooling amongst the agents who would ideally make larger investments; i.e. high valuation buyers and low cost sellers. This pooling mitigates the adverse selection problem that would otherwise arise, due to such agents understanding that their likely interactions would be with 'worse-type' opponents who made lower investments. Sellers with sufficiently high costs, and buyers with sufficiently low valuations are excused from meeting this 'reasonable' standard, and may instead take effort commensurate to their costs/valuations.

A few key points are worth noting. Whenever there is separation, both the buyer and seller condition their investment on their cost of effort *relative* to the buyer's valuation. In the buyer's case, this valuation is known, and so the buyer's investment level depends purely on $\frac{c_B}{v_B}$. By contrast, the seller does not know v_B, and so can only user her expectation of the buyer's valuation (conditional upon the buyer taking more care than her). As in our baseline model, these relative costs of effort are converted into effective relative costs, reflecting the probability that each agent's effort is wasted.

Second, the pooling investment level is precisely the first-best investment for the average agent within the pool, given their effective (relative) costs of effort. This exactly matches the result from the baseline model. Furthermore, if $\hat{c}_S \geq \overline{c}_S$ and $\hat{v}_B \leq \underline{v_B}$ (which will occur if both $E[c_S] + c_B > \overline{c}_S$ and $\frac{1}{E[c_S]} + \frac{1}{c_B} > \frac{1}{\underline{v}_B}$), then there will be complete pooling. If so, then the pooling level will be:

$$\hat{x} = z\left(\frac{c_B + E[c_S]}{E[v_B]}\right)$$

which is precisely the first-best effort level when matching the average buyer with the average seller.