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Regulatory Capacity and Hard-to-Enforce Requirements

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Abstract

In an asymmetric-regulation model, a firm can comply with two regulatory targets, and a regulator can audit the firm to verify compliance. Inspection by the regulator is imperfect, and it assesses the firm's compliance with the targets with different success probabilities. In equilibrium, the firm fully complies only if compliance costs are low. Otherwise, the firm always prioritizes the requirement that is easier to enforce. Expanding regulatory capacity positively affects compliance with the easy-to-enforce target; however, enabling the regulator to enforce both targets can harm compliance with the hard-to-enforce target. When the asymmetry in enforceability is high, an increase in regulatory capacity can negatively affect welfare, highlighting novel considerations for optimal regulatory design.

Keywords: agency resources, asymmetric enforcement, audits, compliance, multitasking, regulation, rules vs. standards

JEL Codes: G28; H11; H32; K20; L51

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1 Introduction

Regulation is often multidimensional, requiring firms to comply with multiple targets or tasks. When some of these tasks are easier to verify than others, the enforceability of the regulation is asymmetric. The literature is full of such cases, ranging from the EU General Data Protection Regulation's transparency principle to the joint use of both numeric and narrative criteria in the U.S. Clean Water Act.[1] In practice, asymmetry in enforceability means that firms and regulators struggle to address compliance with some requirements more than others. Analogous to a multi-task setting in incentive contracting (Holmstrom and Milgrom, 1991) or the debate over rules vs. standards in law-making (Kaplow, 1992), we expect firms to neglect the harder-to-enforce, less-verifiable tasks in a regulatory setting.[2] This outcome is particularly prevalent when agencies and regulators have limited resources and prioritize the easy-to-enforce tasks. Expanding the regulator's *capacity* to address this reallocation of regulatory effort then becomes a policy instrument.

In this paper, we use a stylized model to demonstrate that in a setting with asymmetric enforceability of regulatory targets, expanding regulatory capacity (understood as *general* capacity, or the regulator's ability to simultaneously audit multiple regulatory requirements) alone is insufficient to enhance compliance with hard-to-enforce targets. On the contrary, expanding the regulator's (general) capacity may induce firms to comply with easier-to-enforce targets at the expense of harder ones. This is because a regulator with a low capacity may also not always enforce the easy target; a regulator with expanded capacity, however, is inclined to enforce it with certainty. When the firm's compliance costs are high (and compli-

[1] We discuss these and other examples in greater detail in Section 2.

[2] For empirical evidence on agents allocating more effort towards the highly incentivized and easily measured (or verifiable) tasks, see Hong et al. (2018), Knutsson and Tyrefors (2022), or de Janvry et al. (2023).

ance with both targets becomes prohibitively costly), the anticipated increase in regulator enforcement shifts the firm's attention towards the easier-to-enforce target at the expense of the harder-to-enforce target. We further show that, overall, the asymmetry in enforceability interacts with the effect of increased regulatory capacity in a non-trivial way: when enforceability asymmetry is significant, an increase in capacity can negatively affect welfare.

In Section 3, we propose a simple framework for studying the compliance of multidimensional regulation with asymmetrically enforceable requirements. We build on the game-theory literature on audits and tax avoidance (e.g., Dresher, 1962; Fellingham and Newman, 1985; Graetz et al., 1986; Erard and Feinstein, 1994) and model this interaction as a simultaneous-move game: The firm chooses which requirements to comply with, and the regulator chooses which requirements, if any, to audit. Audits are assumed to be imperfect (non-compliance might go undetected) but error-free (compliance is always identified). Our framework is closest to Heyes (1994), which models the thoroughness of inspection of a single requirement as an endogenous choice. Expanding on this earlier work, we assume asymmetric success probabilities for detecting non-compliance with multiple requirements as given (e.g., Macho-Stadler and Perez-Castrillo, 2006), and focus on the firm's and regulator's choices of which requirements to comply with and to audit. Our model is then akin to an adaptation of the aforementioned Holmström-Milgrom framework to a regulatory setting.[3] Alternatively, it can be interpreted as exemplifying cases in which one activity is regulated by both rules and standards instead of being subject to only one or the other (see, e.g., Ehrlich and Posner, 1974; Diver, 1983; Kaplow, 1992).

In Section 4, we derive equilibrium outcomes for regulators with low capacity

[3]This assumption of asymmetric (and strictly positive) success probabilities distinguishes our analysis from, for instance, Laffont and Tirole (1993, chs. 3.8, 4) where multi-dimensional effort is not verifiable at all.

(that can enforce only one of the requirements and, therefore, have to prioritize) and regulators with high capacity (that can enforce one or both requirements). Our equilibrium analysis demonstrates that enforceability asymmetry leads to (weak) under-compliance with hard-to-enforce requirements, regardless of the regulator's capacity. A high-capacity regulator chooses full inspection of both targets (its dominant strategy), while the firm chooses full compliance only for sufficiently low compliance costs (but no compliance with the hard-to-enforce target otherwise) (Proposition 1). When the regulator is of low capacity, a pure-strategy equilibrium cannot exist. Instead, the regulator randomizes between the two targets, while the firm again chooses full compliance only when compliance costs are sufficiently low. With higher costs, the firm instead randomizes and chooses the easy-to-enforce target with higher probability than the hard-to-enforce target (Proposition 2).[4]

In many instances, expanding the regulator's capacity is a policymaker's choice to counter perceived (mis)allocation of regulatory activity and firms' under-compliance. It is therefore important to understand how such a policy might impact the firms' incentives to comply with a regulation's requirements. In Section 5, we establish that higher capacity is indeed effective in ensuring compliance with the easy-to-enforce requirement, even in the presence of imperfect audits (as is our working assumption). However, expanding *general* regulatory capacity can undermine compliance with the hard-to-enforce requirement.[5] As the regulator with expanded capacity also increases enforcement of the easy-to-enforce target, the firm shifts attention to that target; at sufficiently high compliance costs, this

[4]Our results rely on three simplifying assumptions: First, we model enforceability as an exogenous probability of detecting non-compliance. Second, detecting partial non-compliance is sufficient to halt a firm's activity, preventing any adverse effect. Third, we model away an explicit budget constraint and distinguish cases based on whether the regulator can credibly audit both requirements. We discuss the implications of these assumptions in the concluding section.

[5]Our model abstracts from targeted capacity allocation; we consider only expansions of general capacity, such as broad budget increases or additional staff. Direct (and optimal) reallocation of effort towards specific requirements would not generate the kind of distortions described here.

shift comes at the cost of the firm's compliance with the hard-to-enforce target (Proposition 3). These dynamics are stronger the greater the asymmetry in enforceability. When the difference in enforceability is minimized, the negative effect of an increase in regulatory capacity for welfare is too. This observation suggests that increasing regulators' resources is an effective means of incentivizing compliance only if the underlying regulatory design permits it.

Our paper contributes to the literature on regulation and public economics. First, we study firm compliance and regulatory scrutiny in a setting of multi-dimensional regulation with asymmetric (and imperfect) enforceability.[6] Several empirical investigations have paved our way: de Janvry et al. (2023) show that disproportionate effort goes toward tasks that are "more important and observable to the evaluator" in their work on effort provision by Chinese civil servants. Similar disproportionate efforts toward measurable (and easy-to-enforce) metrics, at the expense of unmeasurable (and hard-to-enforce) ones, have been reported for factory workers in industrial settings (Hong et al., 2018) and when comparing the provision of the same service by privately vs. publicly owned entities (Knutsson and Tyrefors, 2022).[7] Also, Ganglmair et al. (2024) find that uncertainty in regulatory requirements can interact with a regulator's budget constraint, particularly when regulation is multi-dimensional. In this paper, we establish welfare results and regulatory design implications using a model that captures the interdependence between asymmetric targets and their enforceability.

Second, we examine the effect of expanding a regulator's enforcement capac-

[6]Unlike Hunter and Nelson (1995) or Gulen and Myers (2024) (examining differential and possibly asymmetric enforcement by a regulator across states), Agarwal et al. (2014) (documenting how federal and state regulators can implement identical rules differently), or Kalmenovitz et al. (2025) (studying the effects of when multiple regulating agencies oversee a single issue), we study asymmetric enforcement of regulation rules by a single regulator (overseeing the same firm).

[7]For a discussion of potential misallocation of enforcement effort as the consequence of improper regulatory delegation, see McLaughlin and Richards (2025). See also Keeler (1995) for an examination of socially optimal regulation in a model that incorporates varying assumptions about regulatory objectives.

ity. Systematic limitations to regulation have been shown to relate to limited regulatory resources (Stern, 2000; Armstrong and Sappington, 2006) or capacity (Zhang et al., 2025). Regulatory capacity is also related to a more general notion of the state's capacity to enforce rules and implement policy (Fernández-i Marín et al., 2024). For instance, in the context of procurement, Decarolis et al. (2021) show that a negative shock to agency staff can adversely affect innovation. We show that when regulation is multi-dimensional and asymmetrically enforceable, expanding the regulator's general capacity can *reduce* compliance with the harder-to-enforce requirements. This result does not arise in single-dimensional settings and highlights the limits of broad capacity expansions as a policy instrument. We also document that a capacity expansion can reduce welfare if the asymmetry in enforceability is significant.

Third, we contribute to the discussion on rules versus standards in regulatory design (Ehrlich and Posner, 1974; Diver, 1983; Kaplow, 1992). The existing literature evaluates the optimal precision of each regulatory requirement in isolation, thus balancing ex ante specification costs against ex post enforcement costs for a single target. We show that when a rule (an easy-to-enforce target) and a standard (a hard-to-enforce target) coexist, their enforceability levels interact. A wider enforceability gap amplifies the welfare losses from expanding regulatory capacity, because the firm reallocates compliance toward the rule at the expense of the standard. As a result, the optimal precision of a standard cannot be determined independently of the rule it is bundled with. Reducing the ambiguity of hard-to-enforce targets can be more effective than expanding capacity, because it addresses the source of the compliance distortion rather than its symptoms.[8]

[8]This finding echoes the positive discussion in Schauer (2003, 2004), arguing that over time, standards start resembling rules, and vice versa.

2 Asymmetric Enforceability in Regulatory Practice

Regulations are rarely uniform in their enforceability. A common feature across regulatory domains is the coexistence of obligations that differ in how a regulator can verify compliance. This variation poses a central challenge for intra-firm compliance. When confronted with a mix of readily verifiable requirements and more demanding, interpretative standards, it is unclear how firms anticipate enforcement will be carried out. This uncertainty reflects a broader tension between quantitative and qualitative criteria. While the former constrains regulatory discretion by prescribing relatively determinate benchmarks, the latter, typically framed in more open-ended terms, creates flexibility in enforcement.

For example, the General Data Protection Regulation (GDPR),[9] the main data protection regulation in the EU, requires that disclosures relevant for data collection and handling purposes contain a comprehensive list of specified information (Art. 13), while simultaneously mandating that such disclosures be intelligible and written in clear and plain language (Art. 12). The goal is an informative privacy policy. The mere existence of privacy policies or the formal inclusion of required information items is easy to verify and therefore presents an attractive target for regulators. By contrast, assessing whether such a disclosure is intelligible or whether a firm processes data only for the purposes for which it was collected requires regulators to evaluate the quality of the disclosures and the conduct, rather than the mere existence of documentation. This is considerably more demanding and resource-intensive.

[9] Regulation (EU) 2016/679 on the protection of natural persons with regard to the processing of personal data and on the free movement of such data (General Data Protection Regulation, GDPR).

Another example comes from the U.S. Clean Water Act (CWA).[10] The CWA establishes water quality standards through two types of criteria that differ in their enforceability. Numeric criteria (40 CFR 131.11(b)(1)) set specific, measurable thresholds (e.g., concentration limits or temperature) that can be compared directly against monitoring data. Narrative criteria (40 CFR 131.11(b)(2)), by contrast, describe a condition rather than a quantifiable threshold (U.S. Environmental Protection Agency, 2025).[11] This distinction has practical implications for enforcement. Keller and Cavallaro (2008, p. 700) show that regulatory attention tends to concentrate on numeric violations, where non-compliance can be established in an objective and standardized manner, whereas narrative criteria, which require more interpretative assessment, are systematically under-enforced.

A similar dynamic is present in due-diligence regulation (e.g., in the context of human rights), including the EU's Corporate Sustainability Due Diligence Directive (CS3D or CSDDD)[12] and comparable initiatives worldwide. These initiatives aim to enhance the protection and realization of human rights for affected stakeholders (Harrison, 2026). The obligations these initiatives and directives entail have long been criticized for their emphasis on procedural compliance over substantive outcomes (Landau, 2019, p. 18), placing the burden on regulators to operationalize the responsibilities assigned to firms in practice (Deva, 2023, p. 401). As Griffin and Fornasari (2025, p. 12) observe, in the context of the CSDDD, the clearest and most straightforward obligations focus on procedures (such as conducting risk assessments, Art. 5 and 7) rather than on the substantive

[10]Federal Water Pollution Control Act Amendments of 1972 (Clean Water Act, CWA), Pub. L. No. 92-500, 86 Stat. 816 (codified as amended in scattered sections of 33 U.S.C.).

[11]The EPA provides illustrative examples for both numeric criteria ("The ambient water quality criterion for cadmium is recommended to be identical to the existing drinking water standard, which is 10 µg/L (micrograms per liter)") and narrative criteria ("For protection from various oils in water bodies: Surface waters shall be virtually free from floating non-petroleum oils of vegetable or animal origin, as well as petroleum-derived oils.") (U.S. Environmental Protection Agency, 2020).

[12]Directive (EU) 2024/1760 on corporate sustainability due diligence (Corporate Sustainability Due Diligence Directive, CSDDD).

results they should achieve, while provisions that do address substantive results are comparatively vague and open to interpretation (such as measures preventing risks, Art. 8–11).

The described tensions between procedural form and substantive effect connect to the aforementioned distinction between legal rules and standards. Rules refer to relatively precise prescriptions that specify ex ante what conduct is required, whereas standards are framed in more general, often principle-based terms, thereby leaving greater discretion to the regulator during enforcement (Ehrlich and Posner, 1974). Kaplow (1992, p. 577) argues that regulators tend to prefer rules to minimize enforcement costs. While rules are comparatively costly to draft, standards shift these costs to the enforcement stage. Furthermore, rules are considered particularly suitable for situations that recur across a wide range of firms, whereas less frequent or more heterogeneous cases are better addressed through standards (Kaplow, 1992, p. 584).[13] Another point to consider is adaptability. Rules must be revised whenever the regulated environment changes, whereas standards, which are formulated in general terms, are relatively unaffected by such changes and can adapt to new circumstances (Ehrlich and Posner, 1974; Kaplow, 1992; Fon and Parisi, 2007). This makes standards particularly attractive in rapidly evolving regulatory domains, such as those subject to technological change, where the pace of change risks rendering specific rules obsolete and where redrafting is costly (Fon and Parisi, 2007). However, the literature largely examines rules and standards *in isolation*, and does not consider situations of interdependence in which firms operating within the same regulatory framework are subject to both and must determine how to comply with each (as discussed in the foregoing examples).

[13]For a formal model in which the legislature chooses the complexity of a rule to minimize total social costs, see Kaplow (1995).

3 A Model of Asymmetrically Enforceable Regulation

We present a stylized model of asymmetrically enforceable regulation as a simultaneous-move game in which one firm chooses which requirements to comply with, and the regulator chooses which requirement, if any, to audit (e.g., by committing to an audit policy). In this model, we take a specific approach to introduce asymmetry. We provide a detailed discussion of the role of this and other modeling assumptions in Section 6.

A regulated firm acts subject to two distinct regulatory targets, $j = a$ and $j = b$. Compliance costs are c per target.[14] The firm's compliance choice is an action profile $(a, b) \in \{0, 1\} \times \{0, 1\}$ where $j = 1$ indicates compliance and $j = 0$ non-compliance. A regulator enforces these targets by auditing the firm to assess compliance with either target, with neither target, or with both targets. If it finds at least partial non-compliance, it can challenge the firm's activity and prevent any adverse societal effects by sanctioning the firm.[15]

The firm's gross value of its activity is $v > 0$. Compliance lowers the firm's payoffs from the activity so that, given its compliance choices, the firm's net value is $v - ca - cb$. The costs of compliance thus affect the profitability of the firm's activity under regulatory pressure.[16] If the regulator finds (at least partial) non-

[14]We rule out complementarities (or redundancies) across targets; we also do not consider trade-offs that might arise when compliance with one target increases the costs of compliance with another. One such example is the "transparency paradox" (Nissenbaum, 2011). It posits that greater disclosure of a firm's data collection practices (as mandated by the EU GDPR) inherently increases the complexity of the language in firms' privacy policies, thereby increasing the costs of compliance with another GDPR requirement (i.e., greater accessibility of disclosed information).

[15]For a successful challenge, the regulator needs to detect non-compliance with only one requirement; auditing both requirements increases the probability of detecting *at least* one non-compliance.

[16]The cost associated with compliance is not fixed (and sunk before auditing) but, rather, reflects the additional costs associated with operating in accordance with regulatory mandates. We discuss an alternative specification with sunk compliance costs in the concluding section.

compliance and sanctions the firm, the firm does not generate the net value of the activity, and payoffs are zero (regardless of the extent or direction of non-compliance). Given Assumption 1, compliance never leads to negative payoffs:

Assumption 1. $0 < c < \frac{v}{2}$

Non-compliance generates a social loss of $-\gamma < 0$. The regulator's objective is to minimize this social loss. Its payoffs under an unchallenged non-compliant policy are $-\gamma$; and under a challenged policy (with the firm sanctioned) or a compliant policy, they are zero. We assume that inspecting a target requires resources, and that regulators differ in their *capacity*. A *high-capacity* regulator has sufficient resources to inspect both targets. A *low-capacity* regulator can inspect at most one target.[17]

Finally, we assume that audits are imperfect, in that the inspection for target j reveals its state (either $j = 1$ or $j = 0$) with probability $\pi_j < 1$. We take π_j to reflect the inherent verifiability of requirement j as per the requirements' design. To capture asymmetric enforceability, we assume (without loss of generality) that inspecting a has a higher probability of revealing its actual state, $\pi_a > \pi_b$; implicitly, we also assume that compliance and discovery of non-compliance are independent across requirements for both the firm and the regulator. Given Assumption 2, for all feasible values c, the firm does not always strictly prefer not to comply with either of the targets (that is, action profile $(0, 0)$ is never dominant):

Assumption 2. $\frac{1}{2} < \pi_b < \pi_a < 1$.

We summarize the firm's and regulator's pure strategies and respective payoffs in Table 1. The firm chooses *full non-compliance* $(a = 0, b = 0)$, *partial compliance* $((a = 0, b = 1) \vee (a = 1, b = 0))$, or *full compliance* $(a = 1, b = 1)$. To ease notation,

[17] For an alternative approach, one can assume an explicit budget constraint against which the regulator allocates enforcement effort. The outcome of this is a threshold equilibrium that mirrors our reduced-form approach.

Table 1: Normal-Form Representation of the Compliance-Inspection Game

	Payoffs: (firm, regulator)	**Regulator's strategy ($\rightarrow q$)** i_0	i_a	i_b	$i_{a,b}$
Firm's strategy ($\rightarrow p$)	$(0,0)$	$\begin{pmatrix} v, \\ -\gamma \end{pmatrix}$	$\begin{pmatrix} (1-\pi_a)v, \\ -(1-\pi_a)\gamma \end{pmatrix}$	$\begin{pmatrix} (1-\pi_b)v, \\ -(1-\pi_b)\gamma \end{pmatrix}$	$\begin{pmatrix} (1-\pi_a)(1-\pi_b)v, \\ -(1-\pi_a)(1-\pi_b)\gamma \end{pmatrix}$
	$(a,0)$	$\begin{pmatrix} v-c, \\ -\gamma \end{pmatrix}$	$\begin{pmatrix} v-c, \\ -\gamma \end{pmatrix}$	$\begin{pmatrix} (1-\pi_b)(v-c), \\ -(1-\pi_b)\gamma \end{pmatrix}$	$\begin{pmatrix} (1-\pi_b)(v-c), \\ -(1-\pi_b)\gamma \end{pmatrix}$
	$(0,b)$	$\begin{pmatrix} v-c \\ -\gamma \end{pmatrix}$	$\begin{pmatrix} (1-\pi_a)(v-c), \\ -(1-\pi_a)\gamma \end{pmatrix}$	$\begin{pmatrix} v-c, \\ -\gamma \end{pmatrix}$	$\begin{pmatrix} (1-\pi_a)(v-c), \\ -(1-\pi_a)\gamma \end{pmatrix}$
	(a,b)	$\begin{pmatrix} v-2c, \\ 0 \end{pmatrix}$	$\begin{pmatrix} v-2c, \\ 0 \end{pmatrix}$	$\begin{pmatrix} v-2c, \\ 0 \end{pmatrix}$	$\begin{pmatrix} v-2c, \\ 0 \end{pmatrix}$

we refer to $j = 1$ as j, and $j = 0$ as 0, for $j \in \{a, b\}$. A regulator chooses *no inspection* (i_0), *partial inspection* (i_j), or *full inspection* ($i_{a,b}$); the last option is unavailable to a low-capacity regulator.

Consider, for instance, a firm strategy of full non-compliance with $(0, 0)$, and the regulator inspects only target b (so that i_b). Because the regulator detects partial non-compliance with probability π_b and does not detect non-compliance with $(1 - \pi_b)$, adverse societal effects arise with probability $(1 - \pi_b)$, and the regulator's payoffs are $-(1 - \pi_b)\gamma$ (and the firm's $(1 - \pi_b)v + \pi_b \cdot 0$). Now compare these payoffs with the outcome where the regulator inspects both targets ($i_{a,b}$). It does not detect non-compliance of either a or b with probability $(1 - \pi_a)(1 - \pi_b)$ so that its payoffs are $-(1 - \pi_a)(1 - \pi_b)\gamma$.[18] Alternatively, suppose the firm chooses a partial-compliance strategy, complying only with b, and the regulator inspects only b. With this inspection strategy, the regulator cannot detect partial non-compliance and sanction the firm, inevitably resulting in a loss of $-\gamma$.

These two payoff comparisons reflect one of our key assumptions: The regulator's challenge and sanctions are directed at the firm's activity, not at the specific requirement the firm is failing to comply with. In practice, this amounts to the

[18] The firm's payoffs are $(1 - \pi_a)(1 - \pi_b)v + [1 - (1 - \pi_a)(1 - \pi_b)] \cdot 0$.

regulator's challenge to reject the firm's activity in its entirety if it detects any form of non-compliance. Conversely, if any non-compliance goes undetected, it causes the same societal loss, regardless of its nature. In doing so, we argue that the activity itself (characterized by two regulatory targets) is subject to regulatory pressure.

4 Equilibria for Both Regulator Types

We first derive the Nash equilibria for the high-capacity regulator (Proposition 1) and then proceed to the low-capacity regulator (Proposition 2). In Section 5, we examine the equilibrium effects of an expansion of regulatory capacity, present welfare effects, and discuss design implications.

4.1 High-Capacity Regulator

From Table 1, it is immediate to see that full inspection $i_{a,b}$ is the **high-capacity regulator**'s dominant strategy. The following proposition summarizes the Nash equilibria in this scenario:

Proposition 1 (High-Capacity Regulator)**.** *Let* $c_h = \frac{\pi_b}{1+\pi_b} v$*. If* $c < c_h$*, the equilibrium is* $(i_{a,b}, (a, b))$*. If* $c \geq c_h$*, the equilibrium is* $(i_{a,b}, (a, 0))$*.*

Proof. We solve the game by iterated dominance. Full inspection $i_{a,b}$ is the regulator's (weakly) dominant strategy. Firm strategies $(0, 0)$ and $(0, b)$ are dominated by $(a, 0)$ in the resulting reduced game. Firm strategy $(a, 0)$ dominating $(0, b)$ follows from Assumption 2 where $\pi_a > \pi_b$ implies $(1 - \pi_b)(v - c) > (1 - \pi_a)(v - c)$. Firm strategy $(a, 0)$ dominating $(0, 0)$, follows from $(1 - \pi_b)(v - c) > (1 - \pi_a)(1 - \pi_b) v$ if, and only if, $c < \pi_a v$, which holds under Assumptions 1 ($0 < c < \frac{v}{2}$) and 2

$(\pi_a > \pi_b > \frac{1}{2})$. Lastly,

$$v - 2c > (1 - \pi_b)(v - c) \quad \Longleftrightarrow \quad c < \frac{\pi_b}{1 + \pi_b} v = c_h. \qquad \square$$

Because full inspection $i_{a,b}$ is a dominant strategy, the firm always prefers compliance with the easy-to-enforce target, $(a, 0)$, to compliance with the hard-to-enforce target, $(0, b)$. When choosing partial compliance, the firm opts for the target for which non-compliance is easier to detect. Moreover, by Assumption 2, the firm either chooses full compliance (a, b) or non-compliance in b (so that $(a, 0)$). Because $\pi_a > \pi_b$, partial compliance with a dominates not complying at all under the assumption that compliance never leads to negative payoffs for the firm. Moreover, if compliance costs c are small, full compliance is cheap, and the benefits outweigh the costs. Alternatively, when c is high, the firm prefers not to comply with b, hoping its non-compliance goes undetected. All else equal, as the success probability π_b of the hard-to-enforce target increases, the firm strictly prefers to comply with both targets for more values of c.

4.2 Low-Capacity Regulator

For a **low-capacity regulator**, a full audit with $i_{a,b}$ is not feasible by assumption. The regulator always chooses i_a or i_b. It is straightforward to see that a pure-strategy equilibrium cannot exist. Suppose the regulator selects to inspect the easy-to-enforce target, i_a, with probability one. Then, the firm's best response is to choose $(a, 0)$. The regulator is then unable to challenge the non-compliant firm and instead deviates to i_b, inducing the firm to respond with $(0, b)$. But then the regulator's best response is to choose i_a, and so forth. In equilibrium, the regulator will always play a mixed strategy, with strictly positive probabilities on

i_a and i_b.[19]

To construct the resulting equilibria, we find the firm's probabilities for partial compliance $\Pr(a = 1, b = 0) =: p_a$ and $\Pr(a = 0, b = 1) =: p_b$ and no compliance $\Pr(a = 0, b = 0) = 1 - p_a - p_b$ that make the regulator indifferent between inspecting i_a and i_b:

$$\begin{aligned} p_a &= \frac{\pi_a - (1 - p_b)\,\pi_b}{\pi_a}; && (1) \\ p_b &\in \left[0, \frac{\pi_b}{\pi_a + \pi_b}\right]; && (2) \\ 1 - p_a - p_b &= (1 - p_b)\,\frac{\pi_b}{\pi_a} - p_b. && (3) \end{aligned}$$

Note that the firm plays $(a, 0)$ with strictly positive probability (because $p_a > 0$).

The low-capacity regulator has only two undominated strategies, i_a and i_b. We use $q_{a|b}$ and $q_{a|0}$ to denote the regulator's probabilities of playing i_a that make the firm indifferent between $(a, 0)$ and $(0, b)$ or $(a, 0)$ and $(0, 0)$, respectively:

$$\begin{aligned} q_{a|b} &= \frac{\pi_b}{\pi_a + \pi_b}; && (4) \\ q_{a|0} &= \frac{(1 - \pi_b)\,c}{\pi_a v - \pi_b c}. && (5) \end{aligned}$$

The following proposition summarizes the Nash equilibria in this scenario of the low-capacity regulator:

Proposition 2 (Low-Capacity Regulator)**.** *Let*

$$\underline{c}_l := \frac{\pi_b \pi_a}{\pi_b + \pi_a + \pi_b \pi_a} v < \frac{\pi_b \pi_a}{\pi_b + \pi_a - \pi_b \pi_a} v =: \overline{c}_l.$$

Then:

[19] In this context, one can interpret a mixed strategy as a randomized audit schedule to prevent firms from predicting the focus of any audit or, abstracting from our choice of modeling, the audit effort as the interaction between a regulator and a single firm, as cross-firm heterogeneity in the audit targets.

i. *if* $\frac{1}{2} < \pi_b < \pi_a < 1$ *and* $0 < c < \underline{c}_l$*, there is a continuum of payoff-equivalent equilibria: the regulator plays* i_a *with probability* $q \in \left[\underline{q}^b, \overline{q}^b\right]$ *and* i_b *with the remaining probability, and the firm complies with both targets with probability one;*

ii. *if* $\frac{1}{2} < \pi_b < \min\left(\pi_a, \frac{\pi_a}{3\pi_a - 1}\right) \leq \frac{2}{3}$ *and* $\underline{c}_l < c < \overline{c}_l$*, in the unique equilibrium the regulator mixes following* $q_{a|b}$*, and the firm mixes between* $(a, 0)$ *and* $(0, b)$ *with* $p_a = \frac{\pi_a}{\pi_a + \pi_b}$ *and* $p_b = 1 - p_a$*;*

iii. *if* $\frac{1}{2} < \pi_b < \min\left(\pi_a, \frac{\pi_a}{3\pi_a - 1}\right) \leq \frac{2}{3}$ *and* $\overline{c}_l < c < \frac{v}{2}$*, in the unique equilibrium the regulator mixes following* $q_{a|0}$*, and the firm mixes between* $(a, 0)$ *and* $(0, 0)$ *with* $p_a = 1 - \frac{\pi_b}{\pi_a}$ *and* $p_b = 0$*;*

iv. *if* $\frac{\pi_a}{3\pi_a - 1} < \pi_b < \pi_a < 1$ *and* $\underline{c}_l < c < \frac{v}{2}$*, in the unique equilibrium the regulator mixes following* $q_{a|b}$*, and the firm mixes between* $(a, 0)$ *and* $(0, b)$ *with* $p_a = \frac{\pi_a}{\pi_a + \pi_b}$ *and* $p_b = 1 - p_a$*.*

Sketch of the proof. For the proof of the proposition, we find equilibria for all combinations of the relevant parameters. We first construct mixed-strategy equilibria by determining the probabilities p_a (of the firm complying with a) and p_b (of complying with b) that make the regulator indifferent between inspecting requirement a and requirement b, and vice versa. We then check for deviations through direct comparison of the deviation outcomes and obtain the segmentation above and, in particular, that $\underline{q}^b = \frac{c}{(v-c)\pi_a}$ and $\overline{q}^b = \frac{(v-c)\pi_b - c}{(v-c)\pi_b}$. The full proof of the proposition can be found in Appendix A. □

The game has either a unique equilibrium for high compliance costs $c \geq \underline{c}_l$ in which the firm is always more likely to comply with the easy-to-enforce target ($p_a > p_b$); or a continuum of payoff-equivalent equilibria for low compliance costs $c < \underline{c}_l$ in which the firm fully complies with both targets. This multiplicity arises

because the cheaper it is to comply, the easier it is for the regulator to induce the firm to play (a, b).[20]

5 Effects of Expanding Regulatory Capacity

With the equilibria in Propositions 1 and 2 characterized, we now look at the equilibrium effects of an expansion of regulatory capacity and discuss the implications for optimal regulatory design.

5.1 Improving the Regulator's Funding

In equilibrium, the firm never focuses more on the harder-to-enforce target b than on target a (because $p_a \geq p_b$ for both regulator types). That is, even if the regulator has the capacity to inspect both targets, the firm either complies fully (with action profile (a, b)) or ignores b altogether (Proposition 1). In fact, compliance with b can decrease after a regulator receives the capacity to conduct more thorough inspections. While a low-capacity regulator does not always inspect for a, a high-capacity regulator does. When compliance costs are high, anticipated enforcement of a shifts the firm's attention toward the easy-to-enforce target a (because not complying with a is more likely to lead to a challenge as $\pi_a > \pi_b$), thereby deterring b. Formally, after an increase in regulatory capacity, the firm would stop mixing between $(a, 0)$ and $(0, b)$, and instead play $(a, 0)$ with probability one. We summarize our results in Proposition 3.

Proposition 3 (Expanding Regulator's Capacity)**.** *When the regulator's capacity increases, equilibrium compliance with the easy-to-enforce target a increases if*

[20]Proposition 2 accounts for all equilibria except for knife-edge scenarios in which the agents are indifferent between two of the above equilibria. In the Appendix, we demonstrate that no mixed-strategy equilibria exist except those characterized in Proposition 2.

$c > \underline{c}_l$*; compliance with the hard-to-enforce target* b *increases if* $\underline{c}_l < c < c_h$*, but decreases if* $c_h < c < \min\{v/2, \overline{c}_l\}$.

Proof. The proof follows immediately from Propositions 1 and 2 if $0 < \underline{c}_l < c_h < \overline{c}_l < \frac{v}{2}$ holds. The outer conditions are satisfied under Assumptions 1 and 2. It is then sufficient to show that:

$$\underline{c}_l = \frac{\pi_b \pi_a}{\pi_b + \pi_a + \pi_b \pi_a} < \frac{\pi_b}{1 + \pi_b} = c_h \quad \Longleftrightarrow \quad 1 > \frac{\pi_a + \pi_b \pi_a}{\pi_b + \pi_a + \pi_b \pi_a},$$

and:

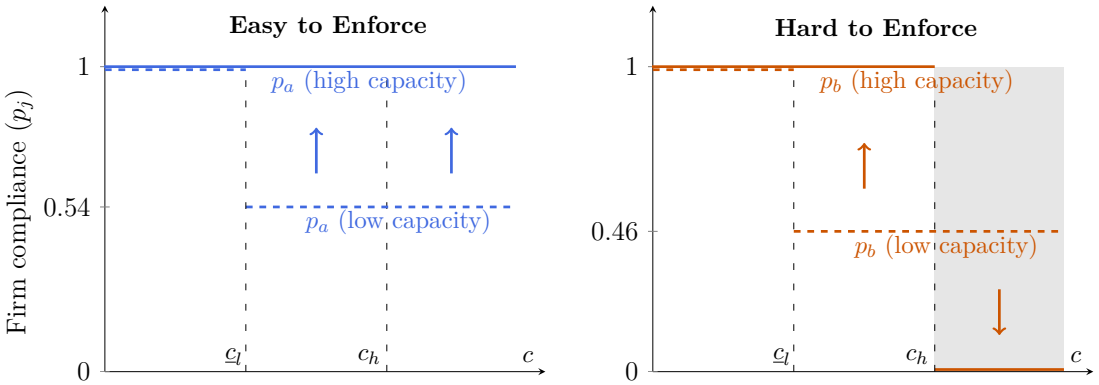
$$c_h = \frac{\pi_b}{1 + \pi_b} < \frac{\pi_b \pi_a}{\pi_b + \pi_a - \pi_b \pi_a} = \overline{c}_l \quad \Longleftrightarrow \quad \pi_a > 1 - \pi_a.$$

Both hold under Assumption 2. □

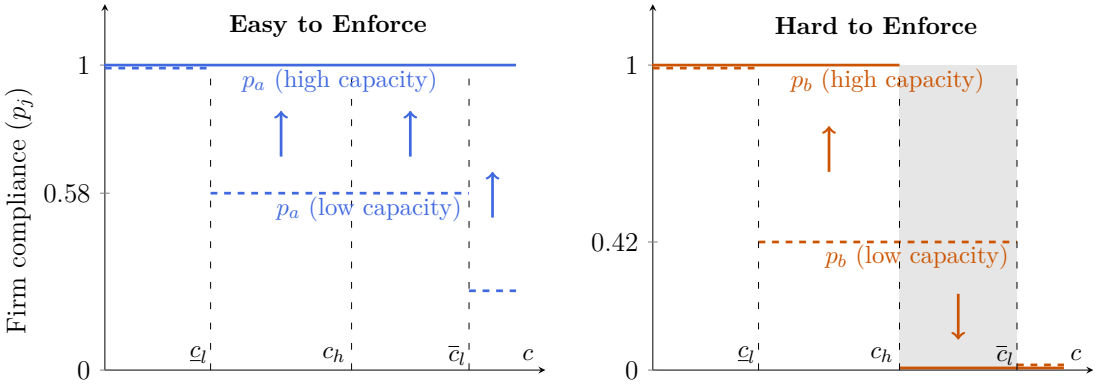
We depict the equilibrium effects of improving a regulator's resources in Figure 1. In the panels on the left-hand side, we plot the firm's compliance (captured by its strategy p_a) with the easy-to-enforce target a (in blue) for the high-capacity regulator (solid lines) and the low-capacity regulator (dashed lines). The panels show that expanding the regulator's capacity has an unambiguously (weakly) positive effect on the firm's compliance with a. In the panels on the right-hand side, we plot the firm's compliance with the hard-to-enforce target b (in orange). For low or high compliance costs, when the firm is fully complying or not complying at all with b, increasing the regulator's capacity does not affect compliance in equilibrium. Conversely, for intermediate values of compliance costs, when under a low-capacity regulator the firm randomizes between both targets for partial compliance (that is, for $c_h < c < \min\{\overline{c}_l, \frac{v}{2}\}$ as per Proposition 2(ii) and (iv)), increasing the regulator's capacity *reduces* compliance with the hard-to-enforce target b.

The result in Proposition 3 (and Figure 1) generates a striking insight for reg-

Figure 1: Effect of Expanding Capacity on Compliance



(a) Low asymmetry case ($\pi_a = 0.75$, $\pi_b = 0.65$)



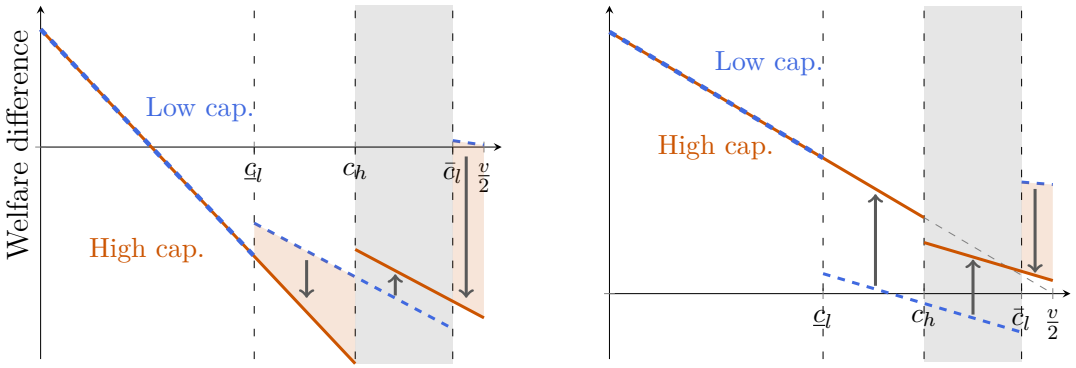
(b) High asymmetry case ($\pi_a = 0.75$, $\pi_b = 0.55$)

Notes: Equilibrium probability of compliance p with the easy-to-enforce target a (blue) and hard-to-enforce target b (orange), for a low-capacity (dashed) and high-capacity (solid) regulator. The exact values of p_a and p_b depend on the relative values of π_a and π_b as per Proposition 2. Arrows indicate the direction of compliance when the regulator increases its enforcement capacity.

ulatory design. When targets are asymmetrically enforceable, regulatory capacity alone is insufficient to enhance compliance with hard-to-enforce targets. While strictly increasing average compliance for high compliance costs ($\overline{c}_l < c < \frac{v}{2}$), expanding regulatory capacity may induce firms to reallocate their compliance efforts for other cost profiles, and ultimately comply with easier-to-enforce targets at the expense of harder ones. The implicit interdependence between asymmetric enforceability and compliance generates a peculiar interaction between regulatory capacity and welfare.

Figure 2 plots the welfare change under low capacity (dashed blue) and high

Figure 2: Welfare Gains from Higher Capacity



(a) Welfare loss $\gamma = 0.25$ (b) Welfare loss $\gamma = 1.00$

Notes: The figure depicts the welfare gains (as the difference between the social loss from non-compliance minus the expected equilibrium costs of compliance) for low-capacity regulators (dashed orange) and high-capacity regulators (solid blue), for $\gamma = 1/4$ in panel (a) and $\gamma = 1$ in panel (b). Arrows indicate the direction of welfare change when the regulator increases its enforcement capacity (net of enforcement costs); shaded regions highlight welfare losses from more regulatory capacity.

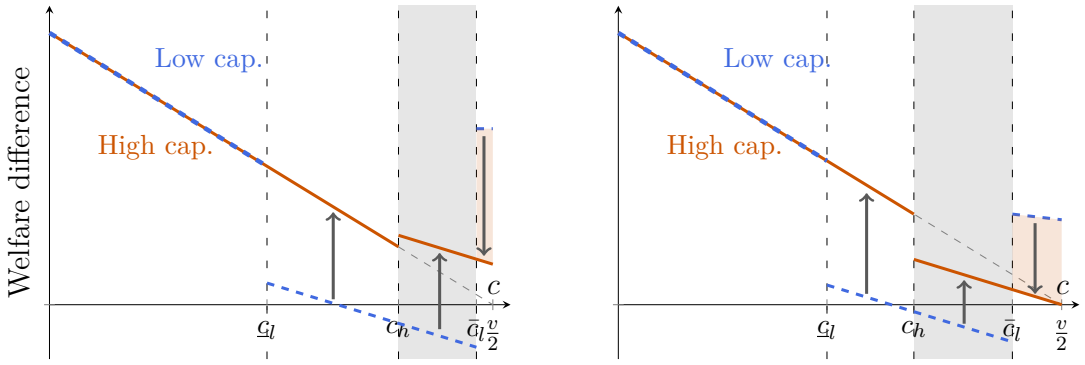
capacity (solid orange) as a function of the compliance cost c, for a low value of γ (left panel) and a high value (right panel). The grey-shaded regions indicate cost ranges in which higher capacity reduces compliance with hard-to-enforce requirements. The orange-shaded regions indicate cost ranges in which expanding capacity *reduces* welfare; that is, the high-capacity regulator produces a smaller welfare gain than the low-capacity regulator. Two mechanisms drive these losses. First, for intermediate compliance costs ($\underline{c}_l \leq c < c_h$ when γ is small), the high-capacity regulator forces full compliance at cost $2c$, while the low-capacity regulator achieves partial compliance at lower cost. The additional compliance is not worth its price: the cost of complying with the second target exceeds the expected harm it prevents. Second, for high compliance costs ($c > \bar{c}_l$), both regimes generate the same expected harm (i.e., $(1 - \pi_b)\gamma$) because target b goes unenforced in either case. The welfare difference arises because the high-capacity regulator always checks for non-compliance with the easy target a (probability $p_a = 1$), compelling the firm to always comply. The low-capacity regulator, in contrast,

does not audit for target a, which allows the firm to occasionally skip compliance without facing detection (probability $p_a = \frac{\pi_a - \pi_b}{\pi_a} < 1$) and, therefore, reducing its burden of complying with a at no additional cost for society.[21] This is not a misallocation across targets but *over-enforcement*: the firm bears compliance costs that produce no welfare benefit. As the right panel shows, when γ is large relative to c, the welfare-improving region dominates; the over-enforcement region at high costs caused by wasteful partial compliance with target a, however, persists regardless of γ.

The welfare consequences of expanding capacity also depend on the degree of enforceability asymmetry. Figure 3 compares two calibrations that hold mean enforceability fixed at $(\pi_a + \pi_b)/2 = 0.65$ but vary the gap: a symmetric case (the limit case with $\pi_a \searrow 0.65$, $\pi_b \nearrow 0.65$) and an asymmetric case ($\pi_a = 0.80$, $\pi_b = 0.50$). The difference between these two cases arises because, when π_b is particularly small relative to π_a, an increase in compliance costs induces the firm to switch from complying with either target a or target b to partially complying only with target a. Indeed, as per Proposition 2(iii), the over-enforcement area only emerges if $\pi_b < \frac{\pi_a}{3\pi_a - 1} < \pi_a$, a condition that requires higher asymmetry the higher π_a is. When compliance costs and enforceability asymmetry are high, making the hard-to-enforce target less ambiguous (i.e., raising π_b) has two positive effects on welfare even without expanding capacity. On the one hand, increasing π_b (for a given, high enough level of π_a) shrinks the parameter space in which over-enforcement emerges. On the other hand, as the firm's probability $p_a = (\pi_a - \pi_b)/\pi_a$ of complying with a in this over-enforcement area decreases as π_b increases, it reduces the probability of wasteful compliance.

[21] Consider the following illustrative example. An informative privacy policy under the GDPR must meet both content and readability requirements. If either is not provided, the policy (here, the firm's activity) is uninformative and generates a social loss. If a policy is unreadable (here: fails to meet the target b), costly improvements in disclosure do not increase informativeness and are therefore wasteful.

Figure 3: The Role of Enforceability Asymmetry



(a) No asymmetry $(0.65, 0.65)$ (b) High asymmetry $(0.80, 0.50)$

Notes: The figure depicts the welfare gains (as the difference between the social loss from non-compliance minus the expected equilibrium costs of compliance) for low-capacity regulators (dashed orange) and high-capacity regulators (solid blue), for increasing asymmetry in enforceability. In panel (a), asymmetry is minimal with $\pi_a \searrow 0.65$ and $\pi_b \nearrow 0.65$; in panel (b), asymmetry is high with $\pi_a = 0.8$ and $\pi_b = 0.5$. Arrows indicate the direction of welfare change when the regulator increases its enforcement capacity (net of enforcement costs); shaded regions highlight welfare losses from more regulatory capacity.

5.2 Discussion and Design Implications

Our welfare analysis points to a design lever that the existing literature on regulatory precision has largely overlooked. The classic framework for choosing between rules and standards weighs the cost of specifying precise ex ante requirements against the cost of case-by-case adjudication ex post (Ehrlich and Posner, 1974; Diver, 1983; Kaplow, 1992; Craswell and Calfee, 1986). This trade-off is evaluated for each regulatory requirement in isolation. The optimal precision of a disclosure rule, for instance, is assessed independently of whatever other obligations the firm faces. The implicit assumption is that the enforceability of one target does not affect compliance with another.

Our model shows that this independence breaks down when multiple targets coexist under a capacity-constrained regulator. The enforceability of target a shapes the firm's equilibrium compliance with target b, and vice versa, because the firm's compliance portfolio and the regulator's inspection strategy are jointly

determined. Consider a policymaker who sets the precision of a hard-to-enforce requirement. They choose, in effect, a value of π_b while taking the easy-to-enforce requirement as given. Evaluated in isolation, a lower π_b (a vaguer standard) may be optimal if it saves drafting costs or preserves regulatory flexibility. But in our setting, a lower π_b widens the enforceability gap, increases $p_a = (\pi_a - \pi_b)/\pi_a$, and amplifies the welfare loss from over-enforcement of the easy target. The precision of the standard, assessed independently, is no longer optimal when it shares enforcement resources with a rule.

Figure 3 illustrates this interdependency. The symmetric calibration (where both targets are equally enforceable) eliminates nearly all welfare losses from capacity expansion. This is not because symmetric enforceability makes regulation more effective in absolute terms. Rather, symmetry removes the firm's incentive to strategically reallocate compliance across targets. The practical implication is that policymakers designing multi-dimensional regulation face a joint optimization problem: the precision of each requirement must account for the enforceability of the requirements it is bundled with. Reducing the ambiguity of hard-to-enforce targets (that is, making them more rule-like) can be more effective than expanding regulatory capacity, precisely because it addresses the source of the distortion rather than its symptoms.

6 Concluding Remarks

Our paper highlights three factors that drive equilibrium behavior in a setting of multidimensional (and asymmetric) regulation. The firm's compliance costs, the regulator's (asymmetric) success probabilities, and the regulator's capacity. While the firm generally complies more with easier-to-enforce targets (in anticipation of stronger regulatory enforcement), the interplay of these factors determines

whether and when we can expect more or less compliance with the hard-to-enforce regulatory target (with weaker anticipated enforcement). We demonstrate that expanding regulatory capacity may indeed lower compliance when it induces firms to prioritize easy-to-enforce targets over more challenging ones. Through this channel, an increase in regulatory capacity might have a net negative effect on welfare if the underlying asymmetry in enforceability is significant.

In our model of asymmetric regulation, we have made several key assumptions that warrant further discussion. First, the asymmetry in regulation stems from an asymmetry in the enforceability of the regulatory targets. While the regulator's success probabilities differ for the two targets, the compliance costs and the targets' underlying values (for both the firm and the regulator) are symmetric. Modeling asymmetry in a single dimension while assuming symmetry in the other dimensions keeps the model tractable. Moreover, we assume the asymmetric success probabilities are exogenous rather than determined by the regulator's (strategic) choice of effort. In an alternative specification, the regulator would allocate effort to target different requirements at different intensities (with higher effort increasing the regulator's success probability). With asymmetric cost of effort, such an approach would likely yield asymmetric success probabilities. However, given our goal of examining a firm's compliance under asymmetrically enforceable regulation by regulators of different capacities, micro-founding the effectiveness of the audit would not enrich our analysis substantively.

Second, detecting *partial* non-compliance (i.e., of just one requirement) is sufficient for the regulator to prevent any adverse societal effects of a firm's activities (by sanctioning the firm, imposing a fine, and possibly compelling a corrective action). For the regulator, the assumption implies that auditing both targets simply increases the probability that the regulator detects at least one non-compliance. This assumption reflects the nature of multi-dimensional regulation. Our objective

is to investigate the role of asymmetric enforceability in regulating a single activity subject to multiple requirements. We thus assume that our regulator does not assign different values to the individual requirements but instead cares about full compliance with respect to the activity itself. It is important to stress this aspect because all requirements in a unified piece of regulation should be understood as aiming toward a common goal: a compliant activity. While not necessarily accurate for all existing examples of regulation, we elect here to abstract from noisy regulatory preferences across different components. In other words, non-compliance in any form undermines the effectiveness of the regulation as a whole and, therefore, generates the same societal loss no matter its specific form.

Third, we take a reduced-form approach to the regulator's budget constraint and the costs of regulation. Enforcing a regulatory target is (symmetrically) costly inasmuch as a constrained regulator (with a binding budget constraint) is not able to enforce both targets (but has to choose), while an unconstrained regulator is able to enforce both. A more comprehensive model specification would include (symmetric) enforcement costs and a budget constraint. Given enforcement costs, there is a critical capacity threshold at which regulators can enforce both targets; below that threshold, regulators enforce only one target. Our approach is reduced-form, assuming a low-capacity regulator with capacity below the threshold and a high-capacity regulator with capacity above the threshold.

Our framework opens several avenues for future research. The rules-versus-standards literature has predominantly studied the design of individual legal directives in isolation. Our analysis suggests that when a regulatory program combines rule-like requirements (precise, easy to verify) with standard-like requirements (vague, hard to verify), interdependencies between them shape both compliance and enforcement in ways that the single-directive perspective cannot capture. Understanding how to balance rules and standards *within* a regulatory program

(rather than choosing between them for each directive separately) is a natural next step. Empirical work that examines real-world regulatory regimes through this lens, moving beyond the monolithic view of regulation as a collection of independent mandates, would complement the theoretical insights developed here.

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A Proof of Proposition 2

We look for mixed strategy equilibria. The regulator is indifferent between i_a and i_b if the firm plays $(a,0)$ with probability p_a; $(0,b)$ with probability p_b; and $(0,0)$ with probability $1-p_a-p_b$. These probabilities satisfy:

$$\begin{aligned}(1-p_a-p_b)(1-\pi_a)(-\gamma) - p_a\gamma - p_b(1-\pi_a)\gamma \\ = (1-p_a-p_b)(1-\pi_b)\quad(-\gamma) - p_a(1-\pi_b)\gamma - p_b\gamma.\end{aligned}$$

Rearranging yields:

$$p_b \in \left[0, \frac{\pi_b}{\pi_a+\pi_b}\right], \quad p_a = \frac{\pi_a-(1-p_b)\pi_b}{\pi_a} > 0, \quad \text{and} \quad 1-p_a-p_b = (1-p_b)\frac{\pi_b}{\pi_a} - p_b.$$

The firm is indifferent between $(a,0)$ and $(0,b)$ or $(a,0)$ and $(0,0)$ if i_a is played with probabilities $q_{a|b}$ or $q_{a|0}$. These probabilities solve:

$$q_{a|b}(v-c) + \left(1-q_{a|b}\right)(1-\pi_b)(v-c) = q_{a|b}(1-\pi_a)(v-c) + \left(1-q_{a|b}\right)(v-c)$$

and

$$q_{a|0}\,(v-c)+\left(1-q_{a|0}\right)(1-\pi_b)\,(v-c)=q_{a|0}\,(1-\pi_a)\,v+\left(1-q_{a|0}\right)(1-\pi_b)\,v$$

so that

$$q_{a|b}=\frac{\pi_b}{\pi_a+\pi_b},\quad q_{a|0}=\frac{(1-\pi_b)\,c}{\pi_a v-\pi_b c}.$$

We check for profitable deviations. In the equilibrium with the firm mixing between $(a,0)$ and $(0,b)$, it holds:

$$\begin{aligned}
E[(a,0)]|_{q_{a|b}}=E[(0,b)]|_{q_{a|b}} &= \frac{\pi_b}{\pi_a+\pi_b}\,(v-c)+\left(1-\frac{\pi_b}{\pi_a+\pi_b}\right)(1-\pi_b)\,(v-c)\\
&= \frac{(v-c)[\pi_a(1-\pi_b)+\pi_b]}{\pi_a+\pi_b}\\
E[(0,0)]|_{q_{a|b}} &= \frac{\pi_b}{\pi_a+\pi_b}\,(1-\pi_a)\,v+\left(1-\frac{\pi_b}{\pi_a+\pi_b}\right)(1-\pi_b)\,v\\
&= \frac{v[\pi_a+\pi_b-2\pi_a\pi_b]}{\pi_a+\pi_b}
\end{aligned}$$

By direct comparison, $E[(a,0)]|_{q_{a|b}}=E[(0,b)]|_{q_{a|b}}>\max\{E[(0,0)]|_{q_{a|b}},v-2c\}$ if, and only if,

$$\begin{aligned}
\frac{1}{2}<\pi_b<\min\left(\pi_a,\frac{\pi_a}{3\pi_a-1}\right)\leq\frac{2}{3} \quad\wedge\quad c<\frac{\pi_b\pi_a}{\pi_b+\pi_a-\pi_b\pi_a}v,\\
\frac{\pi_a}{3\pi_a-1}<\pi_b<\pi_a<1 \quad\wedge\quad c<\frac{v}{2},\\
c<\frac{\pi_b\pi_a}{\pi_b+\pi_a+\pi_b\pi_a}v.
\end{aligned}$$

In the equilibrium in which the firm mixes between $(d,0)$ and $(0,0)$, it holds:

$$\begin{aligned}
E[(a,0)]|_{q_{a|0}}=E[(0,0)]|_{q_{a|0}} &= \frac{(1-\pi_b)\,c}{\pi_a v-\pi_b c}\,(1-\pi_a)\,v+\left(1-\frac{(1-\pi_b)\,c}{\pi_a v-\pi_b c}\right)(1-\pi_b)\,v\\
&= \frac{(v-c)v\pi_a(1-\pi_b)}{\pi_a v-\pi_b c},
\end{aligned}$$

and

$$\begin{aligned}
E[(0,b)]|_{q_{a|0}} &= \frac{(1-\pi_b)\,c}{\pi_a v-\pi_b c}\,(1-\pi_a)\,(v-c)+\left(1-\frac{(1-\pi_b)\,c}{\pi_a v-\pi_b c}\right)(v-c)\\
&= \frac{(v-c)[v\pi_a-c\pi_b-c\pi_b(1-\pi_a)]}{\pi_a v-\pi_b c}.
\end{aligned}$$

Again, by direct comparison, $E[(a,0)]|_{q_{a|0}} = E[(0,0)]|_{q_{a|0}} > \max\{E[(0,b)]|_{q_{a|0}}, v - 2c\}$ if, and only if,

$$\frac{1}{2} < \pi_b < \min\left(\pi_a, \frac{\pi_a}{3\pi_a - 1}\right) \leq \frac{2}{3} \quad \wedge \quad c > \frac{\pi_b \pi_a}{\pi_b + \pi_a - \pi_b \pi_a} v.$$

No other equilibria can exist for $c > \underline{c}_l = \frac{\pi_b \pi_a}{\pi_b + \pi_a + \pi_b \pi_a} v$.

For $c < \underline{c}_l$, the firm never plays $(0,0)$ with positive probability. We compare (a,b) and mixing between $(a,0)$, $(0,b)$. First, (a,b) dominates for $c < \underline{c}_l = \frac{\pi_b \pi_a}{\pi_b + \pi_a + \pi_b \pi_a} v$, and infinite payoff equivalent equilibria exist for $c < \underline{c}_l$. In these equilibria, the firm plays (a,b) with probability one; the regulator mixes between i_a and i_b. Recall that:

$$\begin{aligned} E[(a,0)]|_{q_{a|b}} &= q_{a|b}\,(v-c) + \left(1 - q_{a|b}\right)(1-\pi_b)\,(v-c) \\ E[(0,b)]|_{q_{a|b}} &= q_{a|b}\,(1-\pi_a)\,(v-c) + \left(1 - q_{a|b}\right)(v-c) \end{aligned}$$

We are interested in values q that make the firm weakly better off selecting (a,b) than $(a,0)$ or $(0,b)$. The former case arises when

$$v - 2c > q\,(v-c) + (1-q)\,(1-\pi_b)\,(v-c)\,,$$

which is equivalent to:

$$q \leq \overline{q}^b := \frac{(v-c)\pi_b - c}{(v-c)\pi_b}.$$

The latter arises when $v - 2c \geq q\,(1-\pi_a)\,(v-c) + (1-q)\,(v-c)$, which is equivalent to:

$$q \geq \underline{q}^b := \frac{c}{(v-c)\pi_a}.$$

For all $c \in (0, \underline{c}_l)$, any strategy in which the regulator plays i_a with probability $q_{a|b} \in [\underline{q}^b, \overline{q}^b]$ induces the firm to play (a,b) with probability one. Notice that $c \in (0, \underline{c}_l)$ is a necessary condition for it holds $\underline{q}^b < \overline{q}^b$ to hold.

No other equilibria exist. Suppose a mixed-strategy equilibrium exists that involves the firm playing (a,b) with some positive probability different from one. Then, the regulator will optimally play the best response to the other action with probability one, to which the firm's best response is something different from (a,b).

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