Self-Regulation Versus Government Regulation: An Externality View*

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Abstract

Who should be responsible for industry regulation, a private self-regulatory agency or a public agency? This paper provides a simple framework to analyze the optimal scope of a private self-regulatory organization (SRO) versus government regulation. The trade-off depends on three key elements: externalities, monopoly distortions, and the degree of asymmetric information. Self-regulation is more desirable than government regulation if the degree of asymmetric information between the public regulator and private industry is larger than the size of the monopoly distortion and externalities from the industry to society. An optimal mechanism consists of both self-regulation and government regulation where an SRO internalizes externalities within the industry and the government corrects any distortions generated by the SRO. These insights can be applied to many practical settings and policy discussions—for example, in the context of the financial sector, as with the Financial Industry Regulatory Authority (FINRA).

Keywords: Self-Regulation; Government Regulation; Externalities
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"As I have stated before, it is the private sector, not the public sector, that is in the best position to provide effective supervision."[1]

— Larry Summers in 2000

"No substantially interconnected institution or market on which the system depends should be free from rigorous public scrutiny."[2]

— Larry Summers in 2009

1 Introduction

Self-regulation has been a feature for many industries and professions throughout the world. For example, all firms dealing with securities in the U.S. are required to be members in one of those two self-regulatory organizations (SROs): Financial Industry Regulatory Authority (FINRA) or the Municipal Securities Rulemaking Board. These SROs license their members, write and examine rules for market players, and are also subject to government regulation.[3] Such an arrangement is not unique for security markets but also exists in other sectors such as the nuclear and chemical industry. Interestingly, a similar arrangement is prevalent in many professions such as accounting, law and medicine. Moreover, self-regulation is a worldwide phenomenon. For example, the Swiss Banker Association plays an important role in implementing banking regulation in Switzerland, and the Advertising Standards Authority conducts regulation in UK.

The existence of self-regulation has confused many people for a long time due to the conventional belief that a private organization can never achieve efficient and effective market discipline due to conflict of interest. From the quotes above, it is not hard to see the stark difference between the same Larry Summers before

[1] See "Remarks of Treasury Secretary Lawrence H. Summers to the Securities Industry Association" on Nov. 9, 2000 at http://www.treasury.gov/press-center/press-releases/Pages/ls1005.aspx.

[2] See "Remarks of Lawrence H. Summers Director of the National Economic Council Responding to an Historic Economic Crisis: The Obama Program" on March 13, 2009 at https://www.brookings.edu/wp-content/uploads/2012/04/0313_summers_remarks.pdf.

[3] For a detailed description for FINRA, see http://en.wikipedia.org/wiki/Financial_Industry_Regulatory_Authority.

and after the Great Recession, when he discussed this issue. Given its widespread popularity in different industries, one might expect a comprehensive understanding of self-regulation versus government regulation in the literature. However, some fundamental questions are still unclear. For example, why do some industries have self-regulation? Is it desirable? What is the trade-off between self-regulation versus government regulation? What is the optimal regulation? In this paper, I provide a simple externality driven framework to understand these questions.

Broadly speaking, self-regulation refers to the phenomenon in which an industry establishes a private organization to exercise regulatory authority over industry members. Obviously, its effectiveness depends on whether the government grants an SRO regulatory power. In some industries, the government delegates regulatory power to private sectors, such as FINRA in the securities market. In other industries, although the government still controls regulatory power, the SRO significantly affects industry regulation, such as the Institute of Nuclear Power Operation in the nuclear industry and the American Medical Association in the medical profession — an example of regulatory capture when self-regulation can be conducted in an effective way to shape the industry's regulatory policy. In this paper, I refer to self-regulation as cases where an SRO has de facto regulation over the industry.

There are many explanations for the emergence of self-regulation, such as asymmetric information, externalities, forestalling public intervention, moral concerns, etc. This paper takes an externality view and analyze the scope of self-regulation in addressing market inefficiencies in the economy. By introducing a simple framework, I investigate the trade-off between self-regulation and government regulation. In the end, I also analyze the optimal regulatory mechanism and apply theoretical insights to real-world observations and ongoing policy debates.

The model features three elements affecting the trade-off between self-regulation and government regulation. The first element is about the externalities in the economy. Depending on who is affected, different types of externalities make a large difference. An SRO has an incentive to internalize any externalities within the industry but has no incentive to internalize externalities to the rest of society. Even worse, the SRO's behavior might exacerbate existing distortions. The government, however, has an incentive to correct any types of externalities. The second element is about monopoly distortions. Self-regulation is usually associated with monopoly power since an SRO can coordinate industry behavior through regulation and thus act like a monopolist. The last element is about asymmetric information. Government regulation can correct any distortions if the government has perfect information. However, this is unrealistic — asymmetric information between the public and private sector widely exists, which renders the effectiveness of government regulation and thus creates a role for self-regulation.

To fully understand this trade-off, I impose more informational structure and apply a second-order approximation following Weitzman (1974) and Laffont (1977). I find that self-regulation is more desirable than government regulation if the degree of asymmetric information is larger than the size of monopoly distortion and externalities to society. Moreover, not all information asymmetries matter. In particular, the information about externalities to society does not matter as long as it is uncorrelated with other information. The reason is that the SRO has no incentive to use its superior information on the industrial externalities to society. The government, however, can reduce its information gap with the SRO only when it can make an inference through such information's correlation with other unknown parameters.

I also derive an optimal regulatory mechanism in this economy. The general message is to combine both self-regulation and government regulation where self-regulation aims at correcting externalities within the sector, and government regulation aims at correcting any distortions from self-regulation. Depending on the information structure of the government, the first best allocation might not be implementable. In particular, if the government does not have information about the externalities to society, the first best can never be achieved since an SRO has no incentive to utilize such information. But a second best allocation can be achieved as long as the government has enough information to correct the monopolistic distortions generated by the SRO.

The insights of the general framework can be applied to many empirical observations and theoretical works. I first evaluate the case of existing self-regulation in several industries such as securities markets and nuclear industry. I then apply the model insight to understand the change of regulatory arrangements in the banking sector. I also provide some discussions on regulations in the tech sector, social networks and self-driving cars. In particular, the relative strength of three elements identified in this paper plays an important role in understanding the policy trade-off. Furthermore, their importance can change with the industry development. In the end, I also provide one example to map a three-period model with banking regulation into the theoretical framework provided in this paper. The transformation not only highlights the generality of the model but also adds into existing policy discussions the potential role for self-regulation.

Literature Review

This paper is related to several strands of literature. First, this paper belongs to the literature on understanding the emergence of industrial self-regulation.[4] Existing work has focused on the reasons that firms want to join the SROs for self-regulation in different industries (see King et al. (2011) for an excellent survey on this issue). For example, Maxwell et al. (2000) argue that firms form self-regulation to preempt government regulations. Lyon and Maxwell (2003) and Lyon and Maxwell (2012) analyze the welfare implication of self-regulation with the interaction of government. Consistent with this literature, I provide an economic rationale for firms to join SRO, i.e. to internalize externalities within the sector. Differently, I also analyze the scope of self-regulation over government regulation based on general theoretical framework.

This paper belongs to the literature investigating the benefits and costs of self-regulation. On the one hand, self-regulation tends to generate monopolistic distortions. For example, Shaked and Sutton (1981) argue that a professional group tends to restrict the number of members to gain monopoly power. Moreover, Pirrong (1995) argues that self-regulation is a weak tool to prevent monopoly power by analyzing the self-regulation in commodity exchanges. Furthermore, DeMarzo et al. (2005) show that an SRO tends to behave in favor of the industry rather than consumers. Even so, there are still benefits for the existence of self-regulation. For example, Carson (2011) argues that self-regulation is important for emerging

[4]For example, there are many theoretical work on self-regulation in financial markets including Núñez (2001), Stefanadis (2003), DeMarzo et al. (2005), Núñez (2007) and Aboura and Lepinette (2014), etc.

markets to develop financial markets. Leland (1979), Gehrig and Jost (1995) and Shapiro (1986) model the economic benefit of self-regulation as reducing asymmetric information and argue that its existence might improve the welfare of society. Consistent with the literature, I also show that there is both benefit and cost for self-regulation. Moreover, government regulation can improve the effectiveness of self-regulation.[5] Differently, I provides a unified framework based on externality to analyze the trade-off between self-regulation and government regulation.[6] Furthermore, I show that the insight from the general framework can be applied to many empirical observations and on-going policy discussions.

Last, this paper also contributes to the literature on regulation (see Baron and Myerson (1982) and Armstrong and Sappington (2007)). For example, the optimal policy analysis is similar to the issue of regulating a monopolist (i.e. the SRO) with unknown parameters. Different from previous literature such as Baron and Myerson (1982), there is an economic reason to form the SRO (a monopoly), i.e. internalizing the externality within the industry. Moreover, my approach assumes that there is a Pigovian tax and lump-sum transfer available for the government. Under this assumption, the government can regulate the SRO without knowing the cost parameters in the industry. When this policy is not available, the optimal policy will be similar to the one in Baron and Myerson (1982). Therefore, this paper complements and generalizes the regulation literature. As the focus of this paper is to provide a simple framework for analyzing the desirability of self-regulation, it also simplifies the implementation issue.

The organization of the paper is as follows: Section 2 presents the general model; Section 3 derives an optimal regulatory mechanism; Section 4 provides several applications; and Section 5 concludes.

[5]For example, Kondo (2007) provides evidence that more control of an SRO over customer–firm dispute resolution increases the level of enforcement against a firm's misbehavior. Moreover, DeMarzo et al. (2005) show that government oversight is desirable to reduce the misbehavior of the SRO.

[6]Grajzl and Murrell (2007) also pursue the question of self-regulation versus government as an allocation of lawmaking power and identify conditions for improving social welfare.

2 The Model

In this section, I provide a simple general framework to analyze the scope of self-regulation and government regulation.

2.1 Environment

The economy consists of two sectors: producers and consumers, where each sector has a continuum of individual agents. There is only one good in the economy, which is traded at a market price p. There is a case for regulation in this economy due to the existence of externalities.[7] We consider two types of externalities, both of which are generated by production and negatively affect both producers and consumers. As will be shown later, industrial self-regulation tends to internalize the externality affecting all the producers but has no incentive to internalize the externality affecting consumers, which creates a room for government regulation.

Producers There is a continuum of producers indexed by $i \in [0,1]$. The production process incurs both a private cost $c(x_i;\theta)$ and a social cost $C(X;\Theta)$ (like the technology externality) , where x_i denotes the production for firm i, $X = \int x_i di$ is the overall production in the economy and $\{\theta, \Theta\}$ denotes all the parameters in the cost function. For each individual producer, it only internalizes the private cost function but not the social cost function, which captures the externality within the producer sector. Without loss of generality, we consider the case of negative externality in the producer sector and assume regularity conditions on the cost functions. Formally, $c' > 0, C' > 0$ and $c'' > 0, C'' > 0$ are imposed. Each producer chooses the quantity x_i at market price p to maximize its profit function Π^i given by

$$\Pi^i = px_i - c(x_i;\theta) - C(X;\Theta)$$

Consumers There is a continuum of consumers indexed by $j \in [0,1]$. The individual utility function takes the form of $u(y_j;\phi)$, where y_j is the individual demand

[7] To simplify analysis, I do not provide a micro-foundation for such externalities. In the applications, I provide examples to illustrate how such externalities might evolve.

of consumer j and ϕ is the parameter. Similarly, there is an extra term $U(X;\Phi)$ affected by the aggregate production in the economy (like the consumption externality) where Φ summarizes the parameters. It is assumed that $u' > 0, U' > 0$ and $u'' < 0, U'' > 0$. Consumer j then chooses the quantity of good y_j to maximize her utility given by

$$U^j = u(y_j;\phi) - py_j - U(X;\Phi)$$

Competitive Equilibrium consists of an allocation (x_i^{CE}, y_j^{CE}) and price p such that under price p, x_i^{CE} maximizes Π^i and y_j^{CE} maximizes U^j for $\forall i, j \in [0,1]$. Moreover, the market clears, i.e., $X^{CE} = \int_0^1 x_i^{CE} di = Y^{CE} = \int_0^1 y_j^{CE} dj$.

Given the definition of competitive equilibrium, one can solve the optimality condition for X^{CE}, which satisfies

$$u'(X^{CE};\phi) = c'(X^{CE};\theta) \tag{1}$$

2.2 First Best Allocation

Unsurprisingly, the allocation under competitive equilibrium is not socially optimal given the existence of externalities in the economy. To formalize the idea, we define the first best allocation as the one chosen by a utilitarian social planner who cares equally about consumers and producers. Such an allocation should be considered as an ideal benchmark since it assumes away asymmetric information between the social planner and private agents. The maximization problem is given as follows:

$$\max_X u(X;\phi) - U(X;\Phi) - c(X;\theta) - C(X;\Theta)$$

The optimality condition for the social optimal allocation X^{FB} satisfies

$$u'\left(X^{FB};\phi\right) = U'(X^{FB};\Phi) + c'(X^{FB};\theta) + C'(X^{FB};\Theta) \tag{2}$$

Inefficiency of Competitive Equilibrium By comparing the optimality conditions (1) and (2), it is not hard to see that $X^{CE} > X^{FB}$ since $U', C' > 0$. In other words, there is an over-production in competitive equilibrium. This result is straightforward since the externalies negatively affect both producers and consumers.[8]

Implementation of First Best Allocation Intuitively, implementation of the first best allocation requires a knowledge of all the parameters such as $\{\theta, \Theta, \phi, \Phi\}$. As will be shown later, all the government needs to know is the information on the consumer side, $\{\phi, \Phi\}$. Together with an industrial self-regulatory organization, the first best allocation could be implemented by the government.

2.3 Self-Regulation versus Government Regulation

Regulation is justified since there is a discrepancy between competitive equilibrium and the first best allocation. The interesting question is who should conduct the regulation: an SRO representing producers or a government representing both consumers and producers. This subsection analyzes the trade-off between government regulation and self-regulation.

Self-Regulation

The SRO has an incentive to internalize the externalities within the producer sector but not the externalities to the consumers. In this case, self-regulation cannot implement the first-best allocation X^{FB}. Furthermore, introducing self-regulation also generates monopolistic distortions because the SRO can coordinate the behaviors of individual producer and thus behaves like a monopolist.[9] Formally, the SRO chooses aggregate production X^S to maximize the aggregate profit as below.

$$\begin{aligned} \Pi^S \quad &\equiv \quad \max_{X^S} p(X^S;\phi)X^S - c(X^S;\theta) - C(X^S;\Theta) \\ \text{s.t.} \quad & p(X^S;\phi) = u'(X^S;\phi) \end{aligned}$$

[8]It is the producers who should bear the blame for over-production because the externality term depends on total production by assumption. However, total production equals total consumption in equilibrium. Furthermore, it is possible that consumers are also responsible for the inefficiency if the externality term depends on total consumption.

[9]Indeed, correcting externalities to consumers requires a reduction in production, the same result when the SRO exerts monopolistic distortion. However, the magnitude of reduction in production might differ. Furthermore, depending on assumptions, correcting externalities to consumers might call for an increase in production.

There is no conflict of interest between the SRO and individual producer since they share the same profit function. By internalizing the production externality, both the individual and aggregate profit can been increased. However, self-regulation might hurt the welfare of consumers. Specifically, there are two distortions with self-regulation: the monopoly distortion and the externalities to consumers. As the SRO has power to set rules coordinating industry-level production, it can effectively exercise monopoly power, such as setting a higher industry standard to restrict supply (see Leland (1979) and Shaked and Sutton (1981)). To capture this idea, I model the monopoly distortion by assuming that the SRO can perfectly observe a downward-sloping private demand curve $p(X;\phi) = u'(X;\phi)$.

Government Regulation

Different from the SRO who only cares about profits in the producer sector, a benevolent government maximizes the collective welfare of both consumers and producers. In this case, government regulation can implement the first-best allocation X^{FB} if there is no asymmetric information. However, producers have a better information structure than the government, which renders the effectiveness of government regulation. Specifically, we assume that the government cannot observe $\mathcal{F} = \{\theta, \Theta, \phi, \Phi\}$ but only has a prior distribution. In this case, the government chooses X^G to maximize expected collective social welfare.

$$\max_{X^G} E\left[u(X;\phi) - U(X;\Phi) - c(X;\theta) - C(X;\Theta)\right]$$

A brief comparison between the first best allocation X^{FB} and the allocation under government regulation X^G reveals the cost of government regulation. Ex ante, X^G implements X^{FB} based on the government's prior on the information structure. Ex post, there is some discrepancy since X^{FB} is a function of parameters in $\mathcal{F}$ while X^G is constant. This difference captures two types of frictions for government regulation in reality. First, government regulation suffers from asymmetric information. The inability of precisely targeting the source of externalities becomes a distortion for government regulation. Second, even if the government has the same information structure as the private sector, the government regulation might suffer from slow response to changing environment due to many other restrictions, such as budget constraints, political processes, etc.

Trade-off of Self-Regulation Versus Government Regulation

Neither government regulation nor self-regulation can implement the first best allocation X^{FB}. To study the trade-off between those two, I define a relative welfare function $\Delta^{S/G}$ as below, which measures the welfare benefit of self-regulation over government regulation under the information structure of government.[10] Presumably, one prefers self-regulation if $\Delta^{S/G} > 0$, and government regulation otherwise.

$$\begin{aligned} \Delta^{S/G} &\equiv E[W(X^S;\mathcal{F}) - W(X^G;\mathcal{F})] \\ &\equiv E[u(X^S;\phi) - U(X^S;\Phi) - c(X^S;\theta) - C(X^S;\Theta)] \\ &- \ E[u(X^G;\phi) - U(X^G;\Phi) - c(X^G;\theta) - C(X^G;\Theta)] \end{aligned}$$

where the expectation operator is taken over the prior distribution of information structure $\mathcal{F}$.

To get an analytical solution for $\Delta^{S/G}$, I follow Weitzman (1974) and Laffont (1977) to impose information structure in the model as follows and apply a second-order approximation.

$$\begin{aligned} u(x;\phi) &\approx u\left(X^G;\phi\right) + [\bar{u'} + \phi](x - X^G) + \frac{1}{2}\bar{u''}(x - X^G)^2 \\ U(X;\Phi) &\approx U\left(X^G;\Phi\right) + [\bar{U}' + \Phi](X - X^G) + \frac{1}{2}\bar{U}''(X - X^G)^2 \\ c(x;\theta) &\approx c\left(X^G;\theta\right) + [\bar{c'} + \theta](x - X^G) + \frac{1}{2}\bar{c''}(x - X^G)^2 \\ C(X;\Theta) &\approx C\left(X^G;\Theta\right) + [\bar{C}' + \Theta](X - X^G) + \frac{1}{2}\bar{C}''(X - X^G)^2 \end{aligned}$$

The restrictions on information structure imply that information asymmetries $\mathcal{F}$ only appear up to the first-order derivatives. To normalize, I assume the parameters have zero mean.

[10] Similarly, one could ask the question of whether government regulation (self-regulation) is desirable compared to the unregulated competitive equilibrium. I answer this question by introducing the relative welfare function $\Delta^{CE/G}$ in Appendix A.

Under those assumptions, the relative welfare benefit of self-regulation over government regulation can be approximated as[11]

$$\Delta^{S/G} \approx \frac{\underbrace{E[\phi-\theta-\Theta]^2(\bar{W_S''}-\bar{W''}/2)}_{\text{Information Advantage}}-\underbrace{\bar{W''}/2\left(\bar{u''}X^G+\bar{U'}\right)^2}_{\text{Distortions}}-\underbrace{\bar{W_S''}E[\Phi(\phi-\theta-\Theta)]}_{\text{Information Correlation}}}{(\bar{W_S''})^2}$$

where $\bar{W''} = -\bar{u''}+\bar{U''}+\bar{c''}+\bar{C''} > 0$ and $\bar{W_S''} = \bar{c''}+\bar{C''}-2\bar{u''} > 0$.

The advantage of self-regulation comes from the SRO's superior information about ϕ, θ and Φ. Since X^S is a function of ϕ, θ and Θ, it represents an inherent regulatory advantage of self-regulation. But the superior information can also generate distortions because the SRO uses it differently from the government. On net, the effect of information advantage on relative welfare function is captured by the term $E[\phi-\theta-\Theta]^2(\bar{W_S''}-\bar{W''}/2)/\bar{W_S''}^2$.

Note that the superior information for the SRO does not favor self-regulation over government regulation automatically because the SRO might use those information in a way that generates more distortions. As shown in the relative welfare function, the net benefit from information advantage depends on the sign of $\bar{W_S''}-\bar{W''}/2$. In the case where $\bar{W_S''} < \bar{W''}/2$, the distortions from the SRO's superior information actually dominate, which makes self-regulation less attractive.[12]

The disadvantage of self-regulation comes from two types of distortions. First, the SRO has an incentive to create monopoly distortions captured by the term $\bar{u''}X^G$. Second, the SRO has no incentive to internalize externalities on consumers even if it has superior information about $\mathcal{F}$, captured by $\bar{U'}$. Those distortions make self-regulation less attractive than government regulation, captured by the term $\bar{W''}/2\left(\bar{u''}X^G+\bar{U'}\right)^2/\bar{W_S''}^2$.

The last term captures the information correlation term. Although the government has no information about parameters affecting the SRO's decision ϕ, θ, Θ, it can make an inference through the correlation between Ψ and those param-

[11] See Appendix A for details.

[12] Similarly, one can show that the self-regulation does not automatically dominate competitive equilibrium, especially when the $\Delta^{S/G} < \Delta^{CE/G}$.

eters, which helps reduce information gap. This effect is captured by the term $\bar{W}_S'' E[\Phi(\phi - \theta - \Theta)]/\bar{W}_S''$. Not surprisingly, when the correlation is zero, this term vanishes. In other words, only when Φ provides information about other unknown parameters, it will not affect the trade-off between self-regulation and government regulation. The reason is that only the government cares about the externalities to consumers while the SRO has no use of such information.

Claim 1. ***Trade-off of Self-Regulation Versus Government Regulation***
The trade-off of self-regulation versus government regulation depends on three elements: the degree of asymmetric information, the size of monopoly distortions and the externalities to consumers. Self-regulation is more desirable if

- *degree of asymmetric information is large;*
- *size of monopoly distortions is small;*
- *size of externalities to consumers is small.*

Moreover, the asymmetric information about externalities to consumers is irrelevant for the trade-off unless it provides information about other sources of asymmetric information in the economy.

3 Optimal Regulatory Mechanism

I have established the trade-off between self-regulation and government regulation in the economy. One interesting question is how to utilize the benefits of both the SRO and the government and thus provide an optimal regulatory mechanism. To understand this question, we start from a case in which the government has perfect information such that the first best allocation X^{FB} can be implemented. Then we introduce the asymmetric information problem as before and analyze the optimal regulatory mechanism in this setting.

Proposition 1. ***Optimal Regulation Under Perfect Information***
If government can observe $\mathcal{F}$, it can implement the first best allocation X^{FB} using the following three mechanisms:

1. *Regulating individual consumers by a Pigovian tax* $\tau = U'(X^{FB};\Phi) + C'(X^{FB};\Theta)$ *that is rebated by* $T = \tau X^{FB}$ *or a quantity restriction* $y_j \leq X^{FB}$.

2. *Regulating individual producers by a Pigovian tax* $\tau_0^* = -U'(X^{FB};\Phi) - C'(X^{FB};\Theta)$ *that is rebated by* $T_0^* = -\tau_0^* X^{FB}$ *or a quantity restriction* $x_i \leq X^{FB}$.

3. *Regulating an SRO by a Pigovian tax* $\tau_1^* = -U'(X^{FB};\Phi) - u''(X^{FB};\phi)X^{FB}$ *on production that is rebated by* $T_0^* = -\tau_1^* X^{FB}$.

Moreover, if $\tau_1^* > 0$*, the government can implement the first best allocation* X^{FB} *by delegating regulatory power to a specific number of multiple SROs.*

Proof. See Appendix B.1 □

Proposition 1 provides a benchmark to implement the first best allocation. Clearly, there is not much room for self-regulation if the government has the same information structure as the production sector. In terms of implementation, it is equivalent to purely regulating the consumers or the producers since the demand and supply coincide in equilibrium.[13] Furthermore, there is an equivalent result between price- and quantity-based regulation, a well-known result since Weitzman (1974).

As for the role of self-regulation, government regulation is needed to correct any distortions generated by an SRO. Only if the monopolistic distortions generated by the SRO is larger than the externalities to consumers does there exist a specific market stucture such that the first best allocation can be implemented by the self-regulation. The intuition is straightforward. When the monopolistic distortion is large enough, one SRO tends to reduce production too excessively. The resulting equilibrium with self-regulation is under-production with respect to the first best allocation. Introducing competition between SROs increases production, which moves the equilibrium toward the first best allocation.

The question becomes more interesting once the government has limited information about $\mathcal{F}$. Intuitively, the industry knows $\mathcal{F}$ and utilizes it in its decision-making process. However, the information about Φ plays no role in an SRO's

[13] One direct implication is that government can regulate both the consumers and producers to implement the first best allocation. For simplicity, Proposition 1 only considers regulations either on consumers or producers. For the analysis below, I focus on the regulations on the producer side.

choice X^S due to a lack of incentive. Therefore, unless government has information about Φ, the first best allocation cannot be achieved. In such a scenario, one can expect that the maximum social welfare in an environment where government and an SRO cooperates is $\bar{W}$, which is a second best benchmark.

$$\bar{W} = \max_X u(X;\phi) - E[U(X;\Phi)] - c(X;\theta) - C(X;\Theta) \tag{3}$$

Given that the SRO has the same incentive as the government to reduce externalities within the industry, information about θ and Θ can be utilized properly even if the government does not know directly. The difficulty comes from the information about ϕ as the policy needs to address the distortive incentive for the SRO to extract monopoly rent.

Proposition 2. ***Optimal Regulation If Government Knows Demand Information*** *If the government knows demand information ϕ, the second best allocation $\bar{W}$ can be implemented. Specifically, the government announces a Pigovian tax formula $\tau(X;\phi) = -u'(X;\phi) + \frac{u(X;\phi) - E[U(X;\Phi)]}{X}$ to an SRO to replace its demand function. Meanwhile, an SRO is subsidized by a lump-sum transfer $T = -\tau(X;\phi)X$.*

Proof. See Appendix B.2. □

The intuition behind Proposition 2 is as follows. The SRO has an incentive to internalize the externalities within the production sector. Hence, the government does not need to know the parameters about such externalities. Instead, the SRO has no incentive to internalize the externalities to consumers, whose information asymmetry matters for the government regulation. If the government only knows the demand information ϕ, it can announce a tax schedule to correct the monopolistic distortions from the SRO and implement the second best allocation. Furthermore, if the government also knows the externality parameter Φ, the first best allocation X^{FB} can be implemented (see Corollary 1).

Corollary 1. *If the government knows demand information ϕ and externalities parameter Φ, the first best allocation X^{FB} can be implemented. Specifically, the government announces a Pigovian tax formula $\tau(X;\phi,\Phi) = -u'(X;\phi) + \frac{u(X;\phi) - U(X;\Phi)}{X}$*

to an SRO to replace its demand function. Meanwhile, an SRO is subsidized by a lump-sum transfer $T = -\tau(X;\phi,\Phi)X$.

The second best allocation cannot be implemented if the government has no information about ϕ, which delivers a similar message as in Armstrong and Sappington (2007).[14] In such scenarios, the relative social welfare function should be revised, and I define the following social welfare function $\bar{\bar{W}}$.

$$\bar{\bar{W}} = \max_X E[u(X;\phi) - U(X;\Phi)] - c(X;\theta) - C(X;\Theta)$$

Proposition 3. ***Optimal Regulation for Unknown Demand Information***
If the government does not know demand information ϕ*, the second best allocation* $\bar{W}$ *cannot be implemented. Only* $\bar{\bar{W}}$ *can be implemented through price regulation. Specifically, the government buys goods according to a price menu where* $P(X) = E[u'(X;\phi) - U'(X;\Phi)]$.

Proof. See Appendix B.3. □

The general message from Proposition 1, 2 and 3 can be summarized as follows. First, the optimal mechanisms consist of government regulation, which corrects monopoly distortions and externalities to consumers; and self-regulation, which corrects externalities to producers. Second, the first best allocation can be implemented if the government knows both the information about the demand parameter ϕ and externality parameter Φ. As the focus of this paper is to analyze the scope of self-regulation, I simplify the optimal regulation analysis by assuming that the government has access to both Pigovian tax and lump-sum transfer. When those instruments are not available, the optimal policy will be similar to that analyzed in Baron and Myerson (1982), i.e. regulating a monopoly with unknown cost. Different from the existing framework, this paper focuses more on the economic rationale of self-regulation (i.e. internalizing within sector externalities) and how to combine it with government regulation to derive optimal policy.

[14] In Armstrong and Sappington (2007), they summarize the insights about regulating a monopoly and claim that the first best can be implemented if the regulator knows consumer demand. Here in my settings, if the government knows the demand parameter ϕ, it can only implement the second best since the government also needs to know the externality parameter Φ.

4 Application

In this section, I discuss the applications of the externality driven framework in two ways. First, I apply the insights to understand several empirical observations in the real world. Second, I discuss how to map on-going policy discussions into the general model.

4.1 Mapping to the Real World

Some industries have self-regulation while others have government regulation. The externality driven framework suggests that self-regulation is more desirable when the degree of asymmetric information is large and the distortions from self-regulation is small including both the monopolistic distortion and the externalities outside the industry. To formally evaluate the desirability of self-regulation in different industries, one need to empirically quantify those factors or establish a structural model for counterfactual analysis. Given that those approaches are outside the scope of the paper, I conduct a heuristic analysis using subjective judgments. Specifically, I first analyze two industries that have self-regulation and discuss whether it is justifiable through the length of the model. I then look at the banking industry which used to have self-regulation and is now regulated heavily by the government. In the last, I apply the model insights into the debate on the regulation of the tech sector, social networks, self-driving cars, etc.

As discussed before, self-regulation is widely used in the nuclear industry and the securities markets as the industrial SRO regulates its member by setting rules and standards. There is a social benefit for self-regulation in those industries because of externalities within the sector. For example, service quality matters a lot for transactions in those two sectors because consumers cannot easily identify the quality and thus a low quality product from one individual firm hurts the reputation of the whole industry including high quality product suppliers. Self-regulation, however, can control the overall quality in the industry through its superior information and expertise, which helps maintain the industry reputation and thus reduces externalities within the sector.

However, self-regulation is not warranted if there is no asymmetric information between the industry expert and an outsider. Arguably, specific knowledge and working experience is needed in those industries. Therefore, delegating the regulatory power to the industrial SRO is more efficient than an external regulator for correcting externalities within the sector. Moreover, self-regulation is superior to government regulation if both the monopolistic distortion and the externalities outside the industry are also small. Given that the services provided in both industries can be easily substituted, the monopolistic distortion is likely to be small.[15] As to the size of externalities outside the industry, there are some differences. For the nuclear industry, once there is an accident, it will be catastrophic. Therefore, the externality conditional on the accident is huge. But considering that the probability of such catastrophic in the history is small and will be further driven down with advanced technology, the expected size of those externalities could be potentially moderate but not negligible. Differently, the externalities from the securities market to society tend to be small and even close to zero. Therefore, the case for self-regulation in the securities markets is larger than that in the nuclear industry.

It is also interesting to analyze the case of self-regulation in the banking industry as banks used to self-regulate themselves but are now regulated by the government. Before the establishment of the Federal Reserve System, the banking industry was de facto self-regulated by the New York Clearing House. Afterwards, the government takes over. The model insight can help understand such a change. First of all, there is a case for self-regulation for the banking sector because there are externalities within the banks. For example, in the time of crisis, fire sale in one bank's asset tends to affect other banks' balance sheet. The SRO in the banking sector can thus reduce the externality by coordinating individual bank's behaviors. There is also asymmetric information between the banking sector and an outside regulator, which further justifies the self-regulation over government regulation in the banking sector. The benefit for the self-regulation is likely to dominate its cost in the days when the banking sector is at its early development stage. However, the case for self-regulation weakens nowadays for at least two reasons. First, the monopoly distortion becomes large since the banking industry provides a compre-

[15]For the nuclear industry, the competitor is the traditional power industry. For the securities industry, consumers can simply withdraw their money and put into a traditional banking account.

hensive financial service to the general public and it is very hard for the consumers to find substitute. Second, the externalities from the banking sector to society are very large, as shown by the Great Depression and Great Recession (see Bernanke (1983) for example).[16] Therefore, the cost of self-regulation increases and is more likely to outweigh its benefit up until now, which explains why the banks are heavily regulated by the government all over the world.

Clearly, the factors affecting the cost and benefit of self-regulation change with the technology and economic development. One needs to dynamically evaluate those factors in order to analyze self-regulation. One additional insight from the externality driven framework is that the industry does not have to choose only self-regulation over government regulation or vice versa. The optimal regulation can have both. Given the dynamic changes in the banking industry, it is still worth considering self-regulation as complementary given its flexibility to a changing environment. In the next subsection, I argue that due to the increasing complexity of externalities in the banking sector, the idea of self-regulation is worth considering.

The insights from the model on regulatory arrangement can be applied to many other sectors such as the tech sector, social networks, self-driving cars, etc. There are many ongoing debates on how to regulate such sectors.[17] According to the model, several factors are at play. First of all, it is worth analyzing whether it makes sense to let those sectors self-regulate. A key feature in those sectors is that there is a large amount of asymmetric information. Delegating regulatory power to an industrial SRO can help reduce the within sector externalities such as the quality control and regulation concern. However, the cost of self-regulation in those sectors is equally large. Clearly, it is very hard to find substitute in the tech sector and social networks, with the exception of self-driving cars.[18] Moreover, the market structure in those sectors is far away from perfect competition, typically dominated by a few oligopolies. Therefore, the monopolistic distortions for industrial self-regulation is likely to be significant. The most concerning cost of the potential self-regulation

[16]The externalities are even larger given the existence of deposit insurance and bailout funds.

[17]For example, see the debate on how to regulate the Facebook in https://www.ft.com/content/0f2c8952-a719-11ea-92e2-cbd9b7e28ee6.

[18]Think about the services provided by Google and Facebook. For the self-driving cars, consumers can always choose to drive by themselves.

in those sectors is the externalities outside the sector. Consumers worry about the safety of their personal information collected and stored by those tech and social networks firms, especially when there is a leakage. As for the self-driving cars, who should be responsible for the car accident? Taking those factors together, it is not an easy judgement for the regulatory arrangement in those sectors. Regulating those industries by the government is challenging but self-regulation is also worrisome. Therefore, the optimal strategy for the government is more likely to have both self-regulation and government regulation where the government needs to regulate those industry SROs, paying special attention to the monopolistic distortions and externalities to consumers.

4.2 Theoretical Applications

The general insights in our theoretical framework could be applied to many ongoing policy discussions such as macroprudential and banking regulation. In this section, I provide one simple example in the literature that can be mapped into a general theoretical framework.

In the macro/finance literature, two types of distortions are widely analyzed to justify financial regulation—bailout externality and pecuniary externality.[19] To connect existing analysis with our general framework, bailout funds are essentially externalities from the banking sector (producers in our model) to the general public (consumers) and pecuniary externalities are negative effects between banks, corresponding to consumption externalities $U(X;\Phi)$ and production externality $C(X;\Theta)$ in the model. Therefore, policy discussions based on these types of models should have room for self-regulation in the banking sector. I provide a simple model with the flavor of both pecuniary externalities and bailout in the spirit of Bianchi (2011), Jeanne and Korinek (2010) and Jeanne and Korinek (2019) to analyze the potential role for self-regulation.

The model consists of three time periods $t = 0, 1, 2$ and is inhabited by two types of atomistic agents of mass 1, bankers and investors. Bankers are assumed to be natural borrowers and need to borrow at period 0 and 1 in order to smooth

[19]See Farhi and Tirole (2012), Keister (2015), Bianchi (2016), Jeanne and Korinek (2010), Ma and Nguyen (2018), Ma (2020), Ma and Wei (2020) and Rebucci and Ma (2020).

consumption. Investors are assumed to be natural lenders and have affluent endowments available in three periods. The critical feature of this model is a collateral borrowing constraint, as in Jeanne and Korinek (2010).

Specifically, Bankers have equity e in period 0 and issue debt d_1 to satisfy their consumption c_0. In period 1, after repaying debt d_1,[20] bankers receive an income shock $\tilde{e}$ and 1 unit of asset, which yields a fixed payment y at period 2. Meanwhile, bankers decide the share of asset κ to hold in period 2 and issue another debt d_2 to satisfy consumption c_1. In period 2, bankers receive the payoff from the asset, repay the debt d_2, and consume the remaining amount. However, the bankers' ability to roll over the debt is affected by an imperfect collateral constraint where its value depends on the collateral value. Intuitively, this financial constraint can be rationalized as a limited enforcement or commitment problem in the financial market and thus creates pecuniary externalities. The financial constraint can be expressed as follows.

$$d_2 \leq \phi p$$

where $\phi < 1$ captures the financial friction.

The utility function of the bankers is assumed to be $U^B = c_0 + u(c_1) + c_2$, where in the last period the utility function is assumed to be risk neutral for convenience. Investors are assumed to have an abundant endowment, and their utility functions are $U^I = c_0^I + c_1^I + c_2^I$.

The problem can be solved using backward induction. In period 1, depending on the realization of net worth $m = \tilde{e} - d_1$ there are two states: the unconstrained state where no fire sale happens and the constrained state where the individual banker fire sells his asset. The fire sale creates inefficiencies because the individual does not realize that the asset price is a downward-sloping function and depends on the aggregate net worth of the banking sector, M. In order to map the problem into my general setup, I leave the derivation of value function in Appendix C and write the

[20] Here, the interest rate R can be normalized to 1 due to the specific setting of an investor's utility function.

banker's optimality problem in the fashion of value function in period 0, i.e.

$$\begin{aligned}
\max_{d_0} \quad & c_0 + E[V(m;M)] \\
\text{s.t.} \quad & c_0 = d_0 \\
& m = \tilde{e} - d \\
\equiv \max_{d_0} \quad & \underbrace{d_0}_{px} + \underbrace{E[V(\tilde{e} - d_0, \tilde{E} - D_0)]}_{-c(x;\theta) - C(X;\Theta)}
\end{aligned}$$

To see how this can be mapped into the general framework in Section 2, notice that the price of d_0 is 1 and the $E[V(m;M)]$ is the utility function $-c(x;\theta) - C(X;\Theta)$ for producers, where $\{\theta, \Theta\} = \{\tilde{e}, \phi\}$. The appearance of negative externalities in the banking sector provides room for self-regulation and could yield some economic benefit especially when $\{\theta, \Theta\}$ is unobservable to government.

As to the economic cost of self-regulation, one needs to look at the consumers' utility. In the simple case where it is linear and without bailout, there is no cost of self-regulation. But one can imagine that consumers have the utility form of $U^I = u(c_0^I) + c_1^I + c_2^I$ with $u' > 0, u'' < 0$. Then the monopoly distortions need to be taken into account. As for the externalities from the banking sector to society, one needs to think of the existence of bailouts. Imagine that in period 1, whenever there is a binding constraint, the government will bail out the banks. Suppose that the government can only mitigate part of the constraint due to the cost of taxation. Then there is a tax function T in period 1 deducted from consumer's utility and this T depends on the aggregate level of M. This T function corresponds to the $U(X;\Phi)$ function in my general framework and should be taken into account for the discussion of self-regulation in the banking sector.

Notice that correcting fire-sale externalities requires superior information about $\{\theta, \Theta\}$. Without such information, the policy recommendation, such as the Pigovian tax in Bianchi (2011) and Jeanne and Korinek (2010) is ineffective.[21] Self-regulation, however, could reduce such information asymmetries. An optimal regulatory mechanism in the banking sector should include both government regulation

[21] See Perottia and Suarezb (2011) and Dogra (2014) who analyze the optimal regulation with asymmetric information in a similar setting.

and self-regulation where both focus on different sources of externalities in the economy. This is especially true considering the changing dynamics in the banking sector and slow response of government regulation due to other real world frictions such as political constraints.

5 Conclusion

In this paper, I provide a simple framework for the analysis of self-regulation versus government regulation. I argue that three elements are crucial for the trade-off: externalities, monopoly distortions, and the degree of asymmetric information. Whenever the degree of asymmetric information is larger than the size of monopoly distortions and externalities to society, it is worthwhile to have self-regulation. Moreover, an optimal mechanism consists of both self-regulation and government regulation where self-regulation focuses on externalities in the industry, and government regulation focuses on monopoly distortion and externalities to society.

Based on these insights, I provide examples to understand real-world observations. Moreover, the paper sheds light on current ongoing policy discussions. As long as an economy has the three elements identified in this paper, there is room for analysis of self-regulation versus government regulation. One general takeaway is that optimal regulatory mechanisms should take self-regulation into account.

Future work can be done on this paper. For example, the SRO in the model has the same incentive as the government to internalize the negative externalities and does not have a conflict of interest for misusing the superior information from a social perspective. Moreover, there is no asymmetric information between producers and consumers in the model. Incorporating these features will enrich the analysis. Furthermore, the model can be generalized into a dynamic setting to analyze the dynamic trade-off between self-regulation and government regulation.

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A Relative Welfare Function Analysis

In this section, we analyze the desirability of self-regulation and government regulation by defining a relative welfare function as follows.

$$\Delta^{i/G} \equiv E[W(X^i;\mathcal{F}) - W(X^G;\mathcal{F})]$$

where we consider two cases with $i = \{S, CE\}$ respectively. The former measures the relative welfare between self-regulation and government regulation while the latter measures the relative welfare between competitive equilibrium and government regulation . Given these two functions, $\Delta^{S/CE} = \Delta^{S/G} - \Delta^{CE/G}$ measures the relative welfare between self-regulation and competitive equilibrium.[22]

To get an analytical solution, I follow Weitzman (1974) and Laffont (1977) to impose information structure in the model as below and apply a second-order approximation around $x = X^G$ and $X = X^G$ as follows.

$$\begin{aligned}
u(x;\phi) &\approx u\left(X^G;\phi\right) + [\bar{u'} + \phi](x - X^G) + \frac{1}{2}\bar{u''}(x - X^G)^2 \\
U(X;\Phi) &\approx U\left(X^G;\Phi\right) + [\bar{U'} + \Phi](X - X^G) + \frac{1}{2}\bar{U''}(X - X^G)^2 \\
c(x;\theta) &\approx c\left(X^G;\theta\right) + [\bar{c'} + \theta](x - X^G) + \frac{1}{2}\bar{c''}(x - X^G)^2 \\
C(X;\Theta) &\approx C\left(X^G;\Theta\right) + [\bar{C'} + \Theta](X - X^G) + \frac{1}{2}\bar{C''}(X - X^G)^2
\end{aligned}$$

where the parameters have zero mean.

Under this approximation, the first-order and second-order derivatives are given

[22] I use $\Delta^{S/G}$ and $\Delta^{CE/G}$ to derive $\Delta^{S/CE}$ because it simplifies analysis. As will be shown later, all the functions are approximated around $X = X^G$.

as follows.

$$\begin{aligned}
u'(x;\phi) &= \bar{u'} + \phi + \bar{u''}(x - X^G) \\
U'(X;\Phi) &= \bar{U}' + \Phi + \bar{U}''(X - X^G) \\
c'(x;\theta) &= \bar{c'} + \theta + \bar{c''}(x - X^G) \\
C'(X;\Theta) &= \bar{C'} + \Theta + \bar{C''}(X - X^G) \\
u''(x;\phi) &= \bar{u''} \\
U''(X;\Phi) &= \bar{U}'' \\
c''(x;\theta) &= \bar{c''} \\
C'(X;\Theta) &= \bar{C''}
\end{aligned}$$

Using the approximation for the optimality condition of government regulation, the following relationship holds.[23]

$$\begin{aligned}
0 &= E[u'(X^G;\phi) - U'(X^G;\Phi) - c'(X^G;\theta) - C'(X^G;\Theta)] \\
&\approx E[\bar{u'} + \phi - \bar{U}' - \Phi - \bar{c'} - \theta - \bar{C'} - \Theta] \\
&= \bar{u'} - \bar{U}' - \bar{c'} - \bar{C'}
\end{aligned}$$

Similarly, using the allocations X^S for self-regulation and X^{CE} for competitive

[23]The objective function for a benevolent government is

$$\max_{X^G} E\left[u(X;\phi) - U(X;\Phi) - c(X;\theta) - C(X;\Theta)\right]$$

The optimality condition is

$$E[u'(X^G;\phi)] = E[U'(X^G;\Phi) + c'(X^G;\theta) + C'(X^G;\Theta)] \tag{4}$$

equilibrium, the following relationship holds.[24]

$$\begin{aligned} 0 &= u'(X^S;\phi) + u''(X^S;\phi)X^S - c'(X^S;\theta) - C'(X^S;\Theta) \\ &\approx \bar{u'} + \phi + \bar{u''}X^S - \bar{c'} - \theta - \bar{C'} - \Theta + (\bar{u''} - \bar{c''} - \bar{C''})(X^S - X^G) \\ &= \bar{U'} + \phi - \theta - \Theta + \bar{u''}X^S + (\bar{u''} - \bar{c''} - \bar{C''})(X^S - X^G) \end{aligned}$$

and

$$\begin{aligned} 0 &= u'(X^{CE};\phi) - c'(X^{CE};\theta) \\ &\approx \bar{u'} - \bar{c'} + \phi - \theta + (\bar{u''} - \bar{c''})(X^{CE} - X^G) \end{aligned}$$

The difference between X^G and X^S (X^{CE}) can thus be written as

$$X^S - X^G = \frac{\bar{u''}X^G + \bar{U'} + \phi - \theta - \Theta}{\bar{c''} + \bar{C''} - 2\bar{u''}} \equiv \frac{\bar{u''}X^G + \bar{U'} + \phi - \theta - \Theta}{\bar{W''_S}}$$

end

$$X^{CE} - X^G = \frac{\bar{u'} - \bar{c'} + \phi - \theta}{\bar{c''} - \bar{u''}} \equiv \frac{\bar{u'} - \bar{c'} + \phi - \theta}{\bar{W''_{CE}}}$$

where $\bar{W''_S} = \bar{c''} + \bar{C''} - 2\bar{u''} > 0$ and $\bar{W''_{CE}} = \bar{c''} - \bar{u''} > 0$.

The welfare function is given by

$$W(X;\mathcal{F}) = W(X^G;\mathcal{F}) + (\phi - \Phi - \theta - \Theta)(x - X^G) - \frac{1}{2}\bar{W''}(X - X^G)^2$$

[24]The objective function for an SRO is

$$\begin{aligned} \max_{X^S} \quad & p(X^S;\phi)X^S - c(X^S;\theta) - C(X^S;\Theta) \\ \text{s.t.} \quad & p(X^S;\phi) = u'(X^S;\phi) \end{aligned}$$

The optimality condition is

$$u'(X^S;\phi) + u''(X^S;\phi)X^S = c'(X^S;\theta) + C'(X^S;\Theta) \tag{5}$$

Equivalently, it can be written as

$$u'(X^S;\phi)\left(1 - \frac{1}{E_d(X^S;\phi)}\right) = c'(X^S;\theta) + C'(X^S;\Theta)$$

where $E_d(X^S;\phi)$ is the price elasticity of demand at the point $X = X^S$.

where $\bar{W''} = -\bar{u''} + \bar{U''} + \bar{c''} + \bar{C''} > 0$.

The relative welfare benefit of self-regulation over government regulation can be approximated as

$$\begin{aligned}\Delta^{S/G} &= E\left[(\phi - \Phi - \theta - \Theta)(X^S - X^G) - \frac{1}{2}\bar{W''}(X^S - X^G)^2\right] \\ &= \frac{\underbrace{E[\phi - \theta - \Theta]^2(\bar{W''_S} - \bar{W''}/2)}_{\text{Information Advantage}} - \underbrace{\bar{W''}/2\left(\bar{u''}X^G + \bar{U'}\right)^2}_{\text{Externality}} - \underbrace{\bar{W''_S}E[\Phi(\phi - \theta - \Theta)]}_{\text{Information Correlation}}}{(\bar{W''_S})^2}\end{aligned}$$

The relative welfare benefit of government regulation over competitive equilibrium can be approximated as

$$\begin{aligned}\Delta^{CE/G} &= E\left[(\phi - \Phi - \theta - \Theta)(X^{CE} - X^G) - \frac{1}{2}\bar{W''}(X^{CE} - X^G)^2\right] \\ &= \frac{\underbrace{E[\phi - \theta]^2(\bar{W''_{CE}} - \bar{W''}/2)}_{\text{Information Advantage}} - \underbrace{\bar{W''}/2\left(\bar{U'} + \bar{C'}\right)^2}_{\text{Externality}} - \underbrace{\bar{W''_{CE}}E[(\Phi + \Theta)(\phi - \theta)]}_{\text{Information Correlation}}}{(\bar{W''_{CE}})^2}\end{aligned}$$

One can see that the disadvantage of government regulation is from the asymmetric information captured by the term in the first bracket. The advantage, however, comes from the fact that the government internalizes the externalities (distortions) in the economy, captured by the term in the second bracket. The last bracket is information correlation, which vanishes if there is no correlation in the information set. It comes from the fact that the government can infer the unknown parameters from its prior knowledge about the correlation structure.

Note that superior information does not justify self-regulation (competitive equilibrium) over government regulation automatically because private agents might use those information in a way that makes the existing distortion even worse. Such an effect is captured by the term $\bar{W''_S} - \bar{W''}/2$ in the first bracket of $\Delta^{S/G}$ and the term $\bar{W''_{CE}} - \bar{W''}/2$ in the first bracket of $\Delta^{CE/G}$. In the case where $\bar{W''_S} < \bar{W''}/2$ ($\bar{W''_{CE}} < \bar{W''}/2$), self-regulation (competitive equilibrium) is likely to be inferior to government regulation.

B Proofs

B.1 Proof of Proposition 1

Proof. If government has perfect information about $\mathcal{F}$, it can choose X^{FB} defined by the optimality condition (2). Furthermore, $X^{FB} < X^{CE}$.

To implement X^{FB}, government can regulate either consumers or producers. To regulate the consumers, government can use a Pigovian tax τ on individual consumers and rebate them by a lump-sum transfer T. For the individual consumer j, his objective function is thus

$$\max_{y_j} u(y_j;\phi) - (p+\tau)y_j - U(X;\Psi) + T$$

The optimality condition is

$$p+\tau = u'(y_j;\phi)$$

The optimality condition for producers is unaffected by the policy. Therefore, in equilibrium, the following relationship holds.

$$\tau = u'(X;\phi) - c'(X;\theta)$$

To implement the first best allocation, one can choose $\tau = U'(X^{FB};\Phi) + C'(X^{FB};\Theta)$ and $T = \tau X^{FB}$. Furthermore, one can simply put a quantity restriction $y^j \leq X^{FB}$ on the individual consumer and implement the first best allocation. The reason is that $X^{FB} < X^{CE}$ in equilibrium.

By a similar argument, one can easily show that the first best allocation X^{FB} can be implemented by a tax τ_0^* and a lump-sum transfer T_0^* on an individual producer. For individual producer i, his objective function is thus

$$\max_{x_i} (p+\tau_0^*)x_i - c(x_i;\theta) - C(X;\Theta) + T_0^*$$

The optimality condition is thus

$$p + \tau_0^* = c'(x_i; \theta)$$

The optimality condition for consumers is unaffected by the policy. Therefore, in equilibrium, the following relation holds.

$$\tau_0^* = c'(X; \theta) - u'(X; \phi)$$

By monotonicity of $c' - u'$, choosing $\tau_0^* = -U'(X^{FB}; \Phi) - C'(X^{FB}; \Theta)$ can implement X^{FB} in the decentralized economy. Also $T_0^* = -\tau_0^* X^{FB}$ is implied by government's budget constraint. Similarly, one can also put a production restriction $x^i \leq X^{FB}$ to implement X^{FB} because $X^{CE} > X^{FB}$ in equilibrium.

Now, we consider a case where the government allows the producers to form a industrial SRO and regulates the SRO instead. The SRO thus faces the following maximization problem.

$$\max_X (u'(X; \phi) + \tau_1^*)X - c(X; \theta) - C(X; \Theta) + T_1^*$$

The optimality condition is thus

$$u'(X; \phi) + \tau_1^* + u''(X; \phi)X = c'(X; \theta) + C'(X; \Theta)$$

Hence, one can choose $\tau_1^* = -u''(X^{FB}; \phi)X^{FB} - U'(X^{FB}; \Phi)$ and $T_1^* = -\tau_1^* X^{FB}$ to implement X^{FB}.

Interestingly, if $\tau_1^* = -u''(X^{FB}; \phi)X^{FB} - U'(X^{FB}; \Phi) > 0$, it implies that $X^S < X^{FB} < X^{CE}$. In other words, government needs to subsidize an SRO to implement the first best allocation. It turns out that there exists a specific number of monopolistic competitive SROs such that the first best allocation X^{FB} can be implemented. To see this point, first assume that there exists N SROs in the market for self-regulation and each has a market share of $\frac{1}{N}$. For each of them, the maximization problem is as follows.

$$\begin{aligned} \max_{X_i} \quad & P\left(\tfrac{X_i}{N}+\textstyle\sum_{j\neq i}\tfrac{X_j}{N};\phi\right)X_i - c(X_i;\theta) - C\left(\tfrac{X_i}{N}+\textstyle\sum_{j\neq i}\tfrac{X_j}{N};\Theta\right) \\ \text{s.t.} \quad & P\left(\tfrac{X_i}{N}+\textstyle\sum_{j\neq i}\tfrac{X_j}{N};\phi\right) = u'\left(\tfrac{X_i}{N}+\textstyle\sum_{j\neq i}\tfrac{X_j}{N};\phi\right) \end{aligned}$$

The optimality condition is

$$\frac{1}{N}u''\left(\frac{X_i}{N}+\sum_{j\neq i}\frac{X_j}{N};\phi\right)X_i + u'\left(\frac{X_i}{N}+\sum_{j\neq i}\frac{X_j}{N};\phi\right) = c'(X_i;\theta) + \frac{1}{N}C'\left(\frac{X_i}{N}+\sum_{j\neq i}\frac{X_j}{N};\Theta\right)$$

By symmetry, it implies

$$\frac{1}{N}u''(X^N;\phi)X^N + u'(X^N;\phi) = c'(X^N;\theta) + \frac{C'(X^N;\Theta)}{N}$$

Realize that if $N=1$, there is only one SRO in the market and $X^1 = X^S$; if $N=\infty$, there is a continuum of agents in the market and $X^\infty = X^{CE}$. Moreover, X^N is an increasing function of N. Therefore, if $X^S < X^{FB} < X^{CE}$, by continuity there exists N^* such that $X^{N^{FB}} = X^{FB}$. □

B.2 Proof of Proposition 2

Proof. Suppose government announces $\tau(X;\phi)$ to an SRO and rebates it by $T = -\tau(X;\phi)X$. The objective function for the SRO is

$$\begin{aligned} \max_X \quad & [P(X;\phi)+\tau(X;\phi)]X - c(X;\theta) - C(X;\theta) + T \\ \text{s.t.} \quad & P(X;\phi) = u'(X;\phi) \end{aligned}$$

Notice that by choosing $\tau(X;\phi) = -u'(X;\phi) + \frac{u(X;\phi)-E[U(X;\Phi)]}{X}$, the SRO chooses the second best allocation as in (3) □

B.3 Proof of Proposition 3

Proof. By choosing the price menu as $P(X) = E[u'(X;\phi) - U'(X;\Phi)]$, the government can implement $\bar{\bar{W}}$. To implement, government buys goods from an SRO according to such price menu and sells to the consumer. The difference between selling and buying is transferred to the SRO. □

C Derivation of Value Function

In period 1, define the state variable as $m = \tilde{e} - d_1$ and $M = m$ in equilibrium. The value function can be written as

$$\begin{aligned} V(m;M) = & \max_{d_2,\kappa} u(c_1) + c_2 \\ \text{s.t.} \quad & c_1 = m + d_2 + (1-\kappa)p, \\ & c_2 = \kappa y - d_2 \\ & d_2 \leq \phi p \cdots (\lambda) \end{aligned}$$

The FOCs are

$$\begin{aligned} u'(c_1) &= 1 + \lambda \\ u'(c_1)p &= y \end{aligned}$$

In equilibrium, since the asset is held only by bankers, $\kappa = 1$ and $C_1 = M + D_2$, where the capital letters denote the aggregate level of variables. There are two states in period 1. Define c^* such that $u'(c^*) = 1$ and $\hat{M}$ such that $\hat{M} = c^* - \phi$. Then if $M \geq \hat{M}$, the economy is in the unconstrained state and $c^1 = c^*, d_2 = c^* - m, p = 1$; if $M < \hat{M}$, the economy is in the constrained state and $c_1 = m + \phi \frac{y}{u'(c_1)}$, $p = \frac{y}{u'(c_1)} \equiv p(M)$. Therefore,

$$V(m;M) = \begin{cases} u(c^*) + y + m - c^* & \text{if } M \geq \hat{M} \\ u(m + \phi p(M)) + y - \phi p(M) & \text{if } M < \hat{M} \end{cases}$$