

When to duplicate screening in the selection of projects

Delphine Prady* Florian Schuett†

March 2009

Abstract

We investigate the role of private parties' information in two-tiered systems of project screening. Examples include the patent system and the approval of new drugs: in both cases, a regulator performs a first screen (the patent office in the former, the Food and Drug Administration in the latter); private parties can then initiate a second screen by appealing the regulator's decision to a court of justice. Our results suggest that, by exploiting the information contained in private parties' decisions to appeal the first-stage decision, two-tiered screening can reduce both type-I and type-II errors in the approval process. Our argument thus complements existing rationales for the duplication of screening (Shavell, 1984; Mulligan and Shleifer, 2005; Glaeser and Shleifer 2003).

* Toulouse School of Economics, Manufacture des Tabacs, Aile Jean-Jacques Laffont, Office MF007, 21 allée de Brienne, 31000 Toulouse (France), Email: delphine.prady@univ-tlse1.fr

† European University Institute, Max Weber Programme, Villa La Fonte, Via delle Fontanelle 10, 50014 San Domenico (Italy). Email: florian.schuett@eui.eu

1 Introduction

The selection of projects or the decision to convict a defendant are more or less well-informed decisions. Typically, the relevant information about the specificities of a project or the type of a defendant is shared by several parties. On top of this atomistic sharing, the informed parties may have opposite interests. Therefore, the design of the optimal decision process is not straightforward.

In practice, many examples of project approval involve a two-stage process. Consider for instance the marketing of a new drug in the United States. First, the drug developer must go through the screening of his product by the Food and Drug Administration (FDA). Based on its assessment, the FDA allows or refuses the marketing. When approved, the developer still faces a risk of litigation by claimed injured users. A similar two-stage process is applied for patents. The patent office must examine all demands for patent before granting or rejecting them. After a patent is granted, patentees can still face an opposition suit led by a challenger.

What are the rationales traditionally advanced for the duplication of screening? A pre-trial screening conducted by an independent agency may have several advantages. First, it can play a preventive role by keeping bad projects from coming to market. One could argue that a sufficiently large fine for wrongdoing at the litigation stage should give agents the right incentives for choosing good projects even without the ex ante screening. But this argument doesn't apply if the penalties that the court can order on wrongdoers are bounded by limited liability (Shavell, 1984). Neither does it apply if private agents are ill-informed about the societal consequences of their projects (yet, we would have to assume that the agency is better informed or has lower cost of information acquisition, for some reason).

Second, it may lower the incidence of costly litigation. Projects weeded out by the agency cannot later be litigated. Moreover, harmed consumers have less incentive to file suit when a project has passed the initial screening stage because this information increases the posterior probability that the project is good. Both effects lower the number of projects that will be tried in court. If running the inquisitorial agency involves only a fixed cost, while the cost of the adversarial system is proportional to the number of trials, having an initial screening stage is beneficial for societies with sufficiently large populations (Mulligan and Shleifer, 2005).

Glaeser and Shleifer (2003) point out another possible reason for ex ante regulation which is related to corruption. Since companies only face litigation in the event of an accident, the probability of going to court is relatively small. A large fine is thus needed to induce optimal care ex ante. Of course, the larger the fine, the greater the incentives to subvert the judge. By contrast, regulatory authorities may intervene more frequently, reducing the fine that is needed to ensure compliance. Such a smaller fine is less likely to be the subject of subversion.

In this paper, we provide an alternative rationale for the duplication of screening. We argue that, by exploiting the information contained in private parties' decisions to appeal the first-stage decision, two-tiered screening can reduce both type-I and type-II errors in the approval process. Thus, the duplication of screening may improve the quality of decision-making by reducing both the number of good projects that are rejected and the number of bad projects that are approved.

Suppose society needs to decide whether to approve a project. If approved, good projects yield a net social benefit and bad projects imply a net social loss. All projects may yield private benefits. Furthermore, even good projects may harm some members of society.¹ To separate the wheat from the chaff, society needs to screen projects. Two types of errors endogenously arise in such a screening process. Some good projects can be rejected (type I error) and some bad ones accepted (type II error).

We argue that an important justification for a two-stage screening stems from the possible revelation of hidden information between the screening stages. Under specific conditions, society may acquire a better knowledge of the project's desirability after the first screening. Potential opponents of the first decision also revise their beliefs about the type of the submitted project type and possibly change their decision to litigate, i.e. to trigger a second screening stage. If litigation occurs less often because potential opponents take better-informed decisions in contesting the regulator's rulings, then a two stage screening may reduce type I and II errors *ex ante*.

Our setup is a generalization of Sah and Stiglitz (1986) who compare different organizations of decision making. They focus on two different organizations. In a hierarchy, a project is implemented if it is approved by all the hierarchical levels. In a polyarchy, each individual has the right to accept a project and projects rejected by one are evaluated by the other. Compared to a unique screening process, a polyarchy reduces type I error but increases type II error, while a hierarchy increases type I error but reduces type II error. Thus, neither of them clearly dominates a one stage screening.

Like Sah and Stiglitz (1986), we assume that the evaluator is more likely to accept a good project than a bad project, so that screening is useful to discriminate among projects. The twist with respect to the model of Sah and Stiglitz (1986) is that we do not assume a systematic screen. Under one-stage screening, there is not necessarily any screen at all. Under two-stage screening, there is not always a second screen. Rather, the screens only occur if they are triggered by a private party.

In this context, it is important to define how and when the screen is triggered. We start

¹ Benefits and costs of projects are spread unevenly within the population. We assume that the project itself contains information on its desirability. Therefore, it is not necessary to elicit individual benefits and costs. What matters is to extract the information from the project.

by considering an exogenous triggering mechanism. However, we allow the probabilities of a screen being triggered to vary according to the project's quality, as well as according to the outcome of the first-stage screen in the case of two-stage screening.

The two basic organizational forms considered by Sah and Stiglitz (1986) – polyarchy and hierarchy – are special cases of our setup. In both cases, there is always a first screen. In a polyarchy, there is never a second screen when the project is approved at the first stage, and there is always a second screen when it is rejected. In a hierarchy, it is the opposite. Compared to a single stage of screening, a polyarchy reduces type I error but increases type II error. By contrast, a hierarchy increases type I error but reduces type II error. Therefore, neither of them clearly dominates one-stage screening.

In our more general model, we show that two-stage screening can reduce both types of error. There are two conditions for this to occur. First, under two-stage screening, the second stage must be more likely to be triggered when a good project is rejected than when it is approved, and more likely to be triggered when a bad project is approved than when it is rejected. Second, under one-stage screening, the probability that a screen is triggered even though the project is good must be sufficiently large. The threshold is a function of the trigger probabilities under two-stage screening.

If the first condition is not satisfied, the second stage is useless at best and counterproductive at worst. It is thus important to study when this condition is likely to hold. Assessing the second condition requires knowledge about how the trigger probabilities under one-stage screening are related to those under two-stage screening. Both of these issues require an endogenization of the triggering mechanism, which is the subject of the second part of the paper.

We introduce an informative signal received by private parties. We also assume that triggering a screen is costly. We then show that, under some mild conditions on the quality of the evaluators' decisions, there exists a range of parameters (cost and signal precision) for which two-stage screening dominates one-stage screening with respect to both types of errors.

The remainder of the paper is organized as follows. In section 2, we generalize Sah and Stiglitz's (1986) model while keeping the probabilities of screening exogenous. In section 3, we endogenize these probabilities. Section 4 concludes.

2 A simple model of project screening

There are two types θ of projects: good projects ($\theta = G$), yielding a net social benefit, and bad projects ($\theta = B$), causing a net loss. The type of a project is initially unobservable. It is common knowledge that a fraction q of projects are good. Screening improves the selection

of projects. However, screening is imperfect: an evaluator (judge, regulator) approves a good project with probability $p^G < 1$ and rejects it otherwise. Moreover, he accepts bad projects with some probability $p^B > 0$. We set $p^G > p^B$, in line with our assumption that screening is useful to differentiate projects.

Errors of two different types can occur in this model: good projects being rejected (type I error), and bad projects being approved (type II error). With a single screening stage, the type I error is $1 - p^G$, while the type II error is p^B . Now consider the possibility of adding a second stage. The second stage is triggered with probability $x_{\theta d}$, where d is the decision at the first stage ($d = A$ in case of approval, $d = R$ in case of rejection). For example, x_{GA} is the probability that there is a second stage of screening for a good project that was approved at the first stage. Probabilities of approval remain as in the first stage. The second stage decision overrules the first one. Note that the two basic organizational forms considered by Sah and Stiglitz (1986) – polyarchy and hierarchy – are special cases of this setup: in a polyarchy, $x_{GA} = x_{BA} = 0$ and $x_{GR} = x_{BR} = 1$, while in a hierarchy, $x_{GA} = x_{BA} = 1$ and $x_{GR} = x_{BR} = 0$.

Denote α the type I error and β the type II error. For general $x_{\theta d}$, we have

$$\begin{aligned}\alpha &= p^G x_{GA}(1 - p^G) + (1 - p^G)[1 - x_{GR}p^G] \\ &= (1 - p^G)[1 - p^G(x_{GR} - x_{GA})]\end{aligned}$$

and

$$\begin{aligned}\beta &= p^B(1 - x_{BA}(1 - p^B)) + (1 - p^B)x_{BR}p^B \\ &= p^B[1 - (1 - p^B)(x_{BA} - x_{BR})].\end{aligned}$$

Hence, adding a second screening stage reduces both type I and type II errors compared to the performance of a single screening stage if and only if $x_{GA} < x_{GR}$ and $x_{BA} > x_{BR}$. In that case, $\alpha < 1 - p^G$ and $\beta < p^B$.² The probabilities $x_{\theta d}$ need to depend on whether the first stage decision was correct, so that the triggering of a second stage *provides information* about the project at issue. Specifically, the second stage must be more likely to be triggered when a good project is rejected than when it is approved, and more likely to be triggered when a bad project is approved than when it is rejected.

We have compared so far a single screening stage to a two stage screening, assuming that the triggering of the second stage is informative (and abstracting from possible inefficient duplication of costs). One may question the relevance of this comparison. In fact, a systematic first screening is not necessary. Consider the following setup: there is no systematic first

² This result holds a fortiori if the second stage of screening is more accurate than the first stage, i.e. $p_1^G < p_2^G$ and $p_1^R > p_2^R$.

stage screening, all projects are carried out unless a screening is triggered.³ Good projects are opposed with probability y_G , and bad projects with probability y_B . This triggering mechanism is similar to the second stage screen in the two stage procedure. The y_θ probabilities reflect the moves of private parties just as the $x_{\theta d}$ probabilities do.

In this one-stage procedure with triggering, denote α' the type I error and β' the type II error. We have

$$\begin{aligned}\alpha' &= y_G(1 - p^G) \\ \beta' &= y_B p^B + 1 - y_B.\end{aligned}$$

Compared to the two stage procedure, if $x_{BA} > x_{BR}$ the single stage procedure with triggering always produces more type II errors: $\beta' > p^B > \beta$ (since β' is a convex combination of p^B and 1). However, it does not necessarily produce more type I errors:

$$\alpha \leq \alpha' \iff 1 - p^G(x_{GR} - x_{GA}) \leq y_G. \quad (1)$$

In words, adding a first stage decreases the type I error only if y_G , the probability that an adversarial screening is triggered, is sufficiently large. The results are summarized in the following proposition.

Proposition 1. *A two-stage screening procedure generates fewer type II errors than a one-stage procedure for any $y_B \in [0, 1]$ if $x_{BA} > x_{BR}$. It produces fewer type I errors if and only if $x_{GR} > x_{GA}$ and $y_G > \hat{y}$. The threshold is defined by $\hat{y} \equiv 1 - p^G(x_{GR} - x_{GA})$ and is always strictly lower than 1.*

Two preliminary conclusions emerge from this analysis. First, the informativeness of triggering is crucial to the superiority of a two-stage screening: if the $x_{\theta d}$'s do not satisfy the stated inequalities, the second stage is useless at best and counterproductive at worst. It is thus important to study under what conditions this assumption is likely to hold. Second, it is important to know how y_G is related to p^G , x_{GR} and x_{GA} . Answering these questions requires an endogenization of the triggering mechanism. This is the subject of the next section.

3 Triggering screening

This section takes a simple approach to modeling the probabilities of triggering the second stage screening described in the previous section. Assume that there is a private party (hereafter the “applicant”) that has a vested interest in the approval of the project, and another private party (hereafter the “challenger”) which would benefit from the rejection of the

³ The “first stage” simply rubberstamps all projects.

project. These parties have private information about the type of the project.⁴ Specifically, each private party receives a signal $\sigma \in \{G, B\}$ which is correct with probability $\nu > 1/2$ (that is, $\nu \equiv Pr[\theta = \sigma|\sigma]$). For simplicity, assume that both states of the world are equally likely, so that $Pr[\sigma = \theta|\theta] = \nu$ as well. A favorable decision yields a payoff of 1 to the winning party and a payoff of 0 to the loser. Triggering the screening procedure implies private costs c .

Let us examine how the triggering probabilities depend on c . In the case of a one-stage screening procedure, only the challenger has an incentive to trigger a screen. The challenger triggers screening on reception of signal $\sigma = B$ if and only if

$$c \leq (1 - \nu)(1 - p^G) + \nu(1 - p^B), \quad (2)$$

and does so after $\sigma = G$ if and only if

$$c \leq \nu(1 - p^G) + (1 - \nu)(1 - p^B). \quad (3)$$

Even after a good signal, there is a chance that the regulator rejects the project. If the cost c is not too large, the challenger gambles on an error by one of the evaluators.

In the case of a two-stage procedure, private parties condition their decision to appeal on their signal *and* on the decision at the first stage. Denote $\rho_{\sigma d}$ their posterior belief (derived from Bayes' rule) that the project is valid after signal σ and decision d . For example, a challenger who receives a bad signal and observes that the applicant's project was approved at the first stage believes that the applicant's project is good with probability $\rho_{BA} \equiv Pr[\theta = G|\sigma = B, d = A] = \frac{(1-\nu)p^G}{\nu p^B + (1-\nu)p^G}$. Table 1 provides an overview of posterior beliefs.

Signal	First-stage decision	
	Approval	Rejection
Good	$\rho_{GA} = \frac{\nu p^G}{\nu p^G + (1-\nu)p^B}$	$\rho_{GR} = \frac{\nu(1-p^G)}{\nu(1-p^G) + (1-\nu)(1-p^B)}$
Bad	$\rho_{BA} = \frac{(1-\nu)p^G}{\nu p^B + (1-\nu)p^G}$	$\rho_{BR} = \frac{(1-\nu)(1-p^G)}{(1-\nu)(1-p^G) + \nu(1-p^B)}$

Table 1: Posterior beliefs depending on signal and first-stage decision

If the project is accepted at the first stage, only the challenger has an incentive to appeal. The challenger triggers a second screen after $d = A$ and $\sigma = B$ if

$$c \leq \rho_{BA} (1 - p^G) + (1 - \rho_{BA})(1 - p^B), \quad (4)$$

and does so after $\sigma = G$ if

$$c \leq \rho_{GA} (1 - p^G) + (1 - \rho_{GA})(1 - p^B). \quad (5)$$

⁴ We assume that they cannot communicate their information to the judge or regulator. They can only trigger screening.

If the project is rejected at the first stage, only the applicant has an incentive to appeal. The applicant triggers a second screen after $d = R$ and $\sigma = G$ if

$$c \leq \rho_{GR} p^G + (1 - \rho_{GR})p^B, \quad (6)$$

and does so after $\sigma = B$ if

$$c \leq \rho_{BR} p^G + (1 - \rho_{BR})p^B. \quad (7)$$

To summarize the previous results and perform the analysis that follows, it is convenient to introduce some additional notation for the threshold values of c . Let c_d^1 denote the threshold value of c below which the probability that a screen is triggered given decision $d \in \{A, R, N\}$ (where N denotes no first-stage decision, which applies to the one-stage procedure) is 1. Similarly, let c_d^0 denote the threshold value of c above which the probability that a screen is triggered is 0.

If c is below c_d^1 , the concerned private party always triggers a screen after decision d , regardless of its signal. If c is above c_d^0 , the concerned party never triggers a screen after decision d . And if c is in between the two, the concerned party conditions its decision to trigger on its signal σ , i.e., it only triggers a screen if it receives a favorable signal. For example, if $c \leq c_A^1$, the challenger always appeals first-stage approvals, if $c > c_A^0$, he never appeals, and if $c_A^1 < c \leq c_A^0$, he appeals if and only if he receives a signal indicating the project is bad, $\sigma = B$.

The thresholds for the different first-stage decisions can be easily deduced from inequalities (2) through (7). For easy reference they are reproduced in table 2.

c_d^1	c_d^0
$c_N^1 = \nu(1 - p^G) + (1 - \nu)(1 - p^B)$	$c_N^0 = (1 - \nu)(1 - p^G) + \nu(1 - p^B)$
$c_A^1 = \rho_{GA} (1 - p^G) + (1 - \rho_{GA})(1 - p^B)$	$c_A^0 = \rho_{BA} (1 - p^G) + (1 - \rho_{BA})(1 - p^B)$
$c_R^1 = \rho_{BR} p^G + (1 - \rho_{BR})p^B$	$c_R^0 = \rho_{GR} p^G + (1 - \rho_{GR})p^B$

Table 2: Thresholds c_d^1 and c_d^0 depending on first-stage decision d

Having defined these thresholds, it is straightforward to characterize the probabilities of triggering. Figure 1 provides an overview.

Recall from Proposition 1 that for the two-stage procedure to dominate the one-stage procedure in terms of both types of error, three conditions must be satisfied:

- (i) $x_{BA} > x_{BR}$,
- (ii) $x_{GR} > x_{GA}$, and
- (iii) $y_G > 1 - p^G(x_{GR} - x_{GA})$.

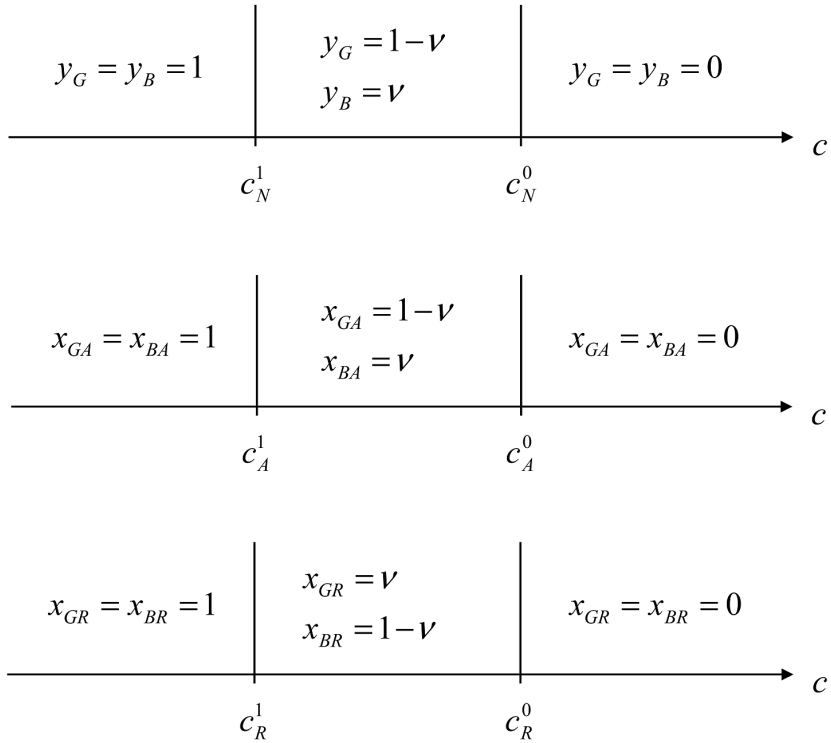


Figure 1: Triggering probabilities as a function of c

The following lemma characterizes the range of c for which all three of these conditions hold.

Lemma 1. *Private parties' decisions to trigger screening satisfy conditions (i), (ii), and (iii) if and only if*

$$c \in [\max\{c_A^1, c_R^1\}, \min\{c_N^1, c_A^0, c_R^0\}].$$

Proof: From figure 1 it is straightforward to see that for condition (i) to be satisfied, it must not be the case that either $x_{BR} = 1$ or $x_{BA} = 0$; in all other cases, $x_{BA} > x_{BR}$. The range of c for which neither is the case is $c_R^1 \leq c < c_A^0$. Similarly, for condition (ii) to be satisfied, it must not be the case that either $x_{GR} = 0$ or $x_{GA} = 1$; in all other cases, $x_{GR} > x_{GA}$. The range of c for which neither is the case is $c_A^1 \leq c < c_R^0$. Combining these two conditions, we have $c \in [\max\{c_A^1, c_R^1\}, \min\{c_A^0, c_R^0\}]$ and thus $x_{BA} = x_{GR} = \nu$ and $x_{GA} = x_{BR} = 1 - \nu$. For condition (iii) to be satisfied, it must not be the case that $y_G \leq 1 - \nu$. Suppose $y_G = 1 - \nu$. Then, condition (iii) is $1 - \nu > 1 - p^G(2\nu - 1)$, which can never be satisfied since ν and p^G must be smaller or equal to 1. Hence, condition (iii) requires $c \leq c_N^1$. ■

We are now ready to state the main result of this section.

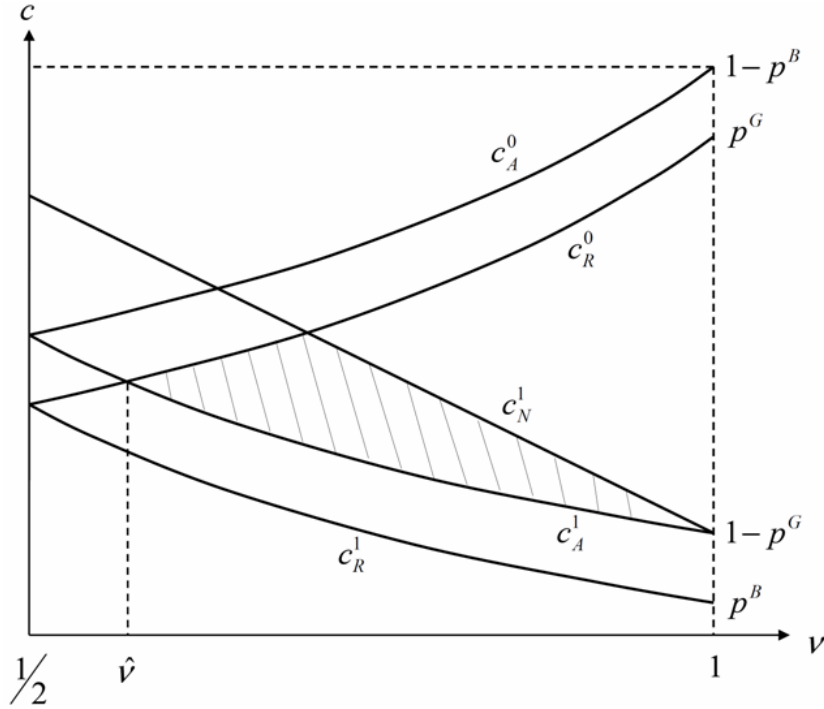


Figure 2: Two stage vs. single screening with respect to type I error

Proposition 2. *Suppose $p^G > 1/2$ and $p^G + p^B < 1$. Then, there exists a nonempty set of parameters in the (ν, c) space for which a two-stage screening procedure dominates a one-stage procedure, in the sense of reducing both type I and type II errors.*

Proof: Define $\hat{\nu}$ such that $c_A^1(\hat{\nu}) = c_R^0(\hat{\nu})$ and $\tilde{\nu}$ such that $c_A^1(\tilde{\nu}) = c_R^0(\tilde{\nu})$. The assumption $p^G > 1/2$ implies that $\hat{\nu} < 1$. The assumption $p^G + p^B < 1$ implies that $\tilde{\nu} < \hat{\nu}$. Thus, for $\nu > \hat{\nu}$, the set $[\max\{c_A^1, c_R^1\}, \min\{c_A^0, c_R^0\}]$ is nonempty. Moreover, the assumption $p^G + p^B < 1$ implies that $c_N^1(\nu) \geq c_A^1(\nu)$ for all $\nu \in [1/2, 1]$. ■

Proposition 2 is illustrated in figure 2.

4 Conclusion

We have investigated the role of private parties' information in two-tiered systems of project screening. Examples include the patent system and the approval of new drugs: in both cases, a regulator performs a first screen (the patent office in the former, the Food and Drug Administration in the latter); private parties can then initiate a second screen by appealing the regulator's decision to a court of justice. Our results suggest that, by exploiting the

information contained in private parties' decisions to appeal the first-stage decision, two-tiered screening can reduce both type-I and type-II errors in the approval process. Our argument thus complements existing rationales for the duplication of screening.

References

- [1] Glaeser E. and Shleifer A. (2003), "The rise of the Regulatory State", *Journal of Economic Literature*, Vol. 41, pp. 401-425.
- [2] Froeb L. and Kobayashi B. (2001), "Evidence production in adversarial vs. inquisitorial regimes", *Economics Letters*, Vol. 70, pp. 267-272.
- [3] Mulligan C. and Shleifer A. (2005), "The Extent of the Market and the Supply of Regulation", *The Quarterly Journal of Economics*, Vol. 120, pp. 1445-1473.
- [4] Sah R. and Stiglitz J. (1986), "The Architecture of Economic Systems: Hierarchies and Polyarchies", *The American Economic Review*, Vol. 76, pp. 716-727.
- [5] Shavell S. (1984), "A Model of the Optimal Use of Liability and Safety Regulation", *The RAND Journal of Economics*, Vol. 15, pp. 271-280.
- [6] Shin H. (1998), "Adversarial and Inquisitorial Procedures in Arbitration", *The RAND Journal of Economics*, Vol. 29, pp. 378-405.