# The Efficiency of Mediocrity Strategic Organization Design in Uncertain Environments*

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**Abstract**

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## 1 Introduction

A key feature in the organization design of firms is who makes decisions in an organization, and how. For example, Managers of a geographical unit decide to enter new geographical markets (Raveendran, 2019), R&D managers decide to put an innovation forward for patenting (CITATION), or fund managers select (individually or jointly) which stocks to include in the fund's portfolio (Csaszar, 2012). It is obvious that the way that the decision-making process is set up has important implications for the strategies firms will eventually implement. If a project needs multiple "signatures" by independent decisionmakers to go ahead, the organization will end up choosing less projects, but will make less mistakes ex-post than an organization that realizes projects with just one backer (Sah and Stiglitz, 1986; Csaszar, 2012).

This allows for a stringent evaluation of different organization designs contingent on the objective of the firm: If the firm wants to avoid missing out on potentially profitable projects (i.e. minimize errors of omission), it should pick a design that imposes few secondary checks and balances. Conversely, if the firm wants to keep mistakes low (i.e. errors of commission), an organization design requiring multiple positive votes is more effective. This is the essence of Strategic Organization Design: picking an organization design that supports the firm's overall strategy.

Most prior work agrees that an organization design should be either "centralized" or "decentralized", or in Sah and Stiglitz's 1986 parlance, a hierarchy or a polyarchy. Interestingly, the organization's environment may determine the strategy a firm should optimally pursue, suggesting in turn that organization design has to correspond to the external environment. For example, if payoffs are highly skewed, i.e. positive outcomes are highly profitable but rare, while negative ones are common but limited in their losses (this would describe the setting of venture capitalists for example), a different design would be called for than for the reverse setting (high losses with low probability) with the same expected payoff of a project. This is why the FDA has multiple stages at which a proposed drug can fail (thus avoiding launch of harmful drugs), while venture capitalists have individual "champions" of proposals who can back it without further approval (thus ensuring that promising projects are not rejected through multiple approval stages).

A related line of work has developed the concept of ambidexterity, which captures several structural and XXX measures to unite both an ability to select safe projects (thereby improving the status quo in a situation where errors of commission are more harmful) and to take bets on risky projects (to ensure future viability through engaging in more risky behavior that are associated with costly errors of omission). The literature has established measures supporting ambidexterity through temporal or spatial separation (XXX), or through hybrid organizational forms (**?**). What is interesting is that the concept of ambidexterity recognizes that organizations may have to accommodate multiple, possibly conflicting goals, and find structural solutions to support them.

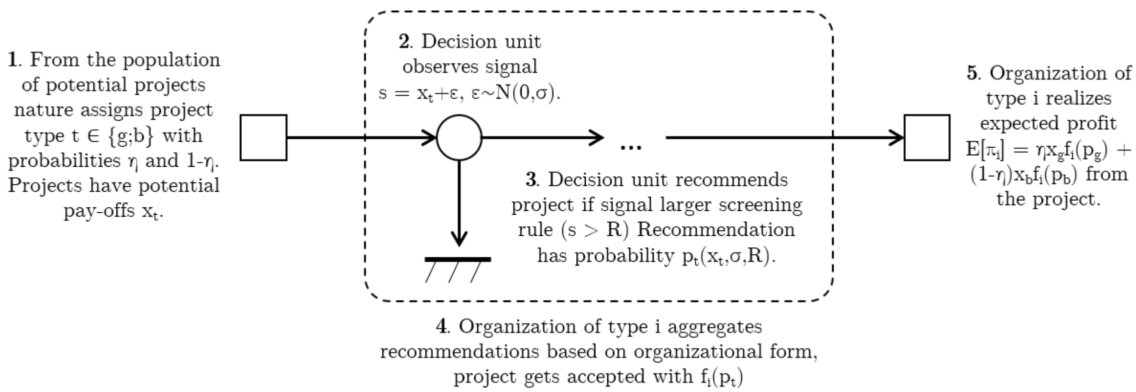
We develop a model from the primitives of organization design, the way decisions are taken in the firm. We show that, contrary to prior work, it can be optimal to select an organization design that is neither optimal in avoiding errors of commission, i.e. it is more permissive than a hierarchy, nor in avoiding errors of omission, i.e. it is more restrictive than a polyarchy. This is surprising as intuition would suggest that the relative cost of errors should determine whether one of the two extreme forms dominates (Raveendran, 2019). Instead, we show that not just the relative cost, but also the XXX affects the respective profitability of the different designs.

## 2 Model

### 2.1 Design

We approach the issue with a simple design based on Sah and Stiglitz (1986). Our interest in analyzing mixture forms makes some changes to their original design necessary. Additionally, for reasons of tractability and to ease interpretation, we make some simplifications to their original formulation, but keep the main structure intact. Figure 1 shows the structure of the model used here. All parameters used in the model and their intuitive explanations are also summarized in Table A.1 in the appendix.

*Figure 1* – Structure of the model.




The organization operates in an environment in which they have access to an population of potential projects with type $t \in \{g, b\}$. As shown in step 1 of Figure 1, good projects (type $g$) appear with a probability of $\eta$, while bad projects (type $b$) are prevalent with probability $1 - \eta$. In the model, draws from the population of potential products are independent, such that we abstract from learning by the organization. If a good project is taken into the the organization's set of realized projects, it will be carried out and lead to a pay-off of $x_g > 0$. Bad projects in this set lead to a pay-off of $x_b < 0$. The organization cannot discriminate the projects ex-ante and needs to evaluate them individually as indicated in step 2 of Figure 1. When evaluated by a decision unit, the projects give a signal. The signal $s = x_t + \varepsilon$ is comprised of the inherent quality of the product and a random disturbance $\varepsilon$ which we will assume to be normally distributed with mean 0 and standard deviation $\sigma$. This error term characterizes the uncertainty inherent in the environment that organizations operate in.

Organizations are comprised of decision units. The decision of an organization to include a project in the set of realized projects is based on the individual decisions of the decision units. The way in which these individual decisions are aggregated is determined by the organizational form.

In addition, the organization implements a screening rule $R$ which is used by all decision units in it. Decision units evaluate projects and give them a positive or a negative evaluation. As is shown in step 3 of Figure 1, the probability for a positive evaluation is determined by the project's signal and the screening rule $R$ of the organization. Specifically, if $s > R$, the evaluation is positive, while a negative evaluation follows from $s \leq R$. Due to our assumption of a normally distributed $\varepsilon$, we know the probability of a positive evaluation to be

$$p_t = prob(s > R) = 1 - F(R - x_t, \sigma). \quad (1)$$

Where $F(y, \sigma)$ denote the cumulative distribution function of the normal distribution with mean zero and standard deviation $\sigma$ at value $y$.

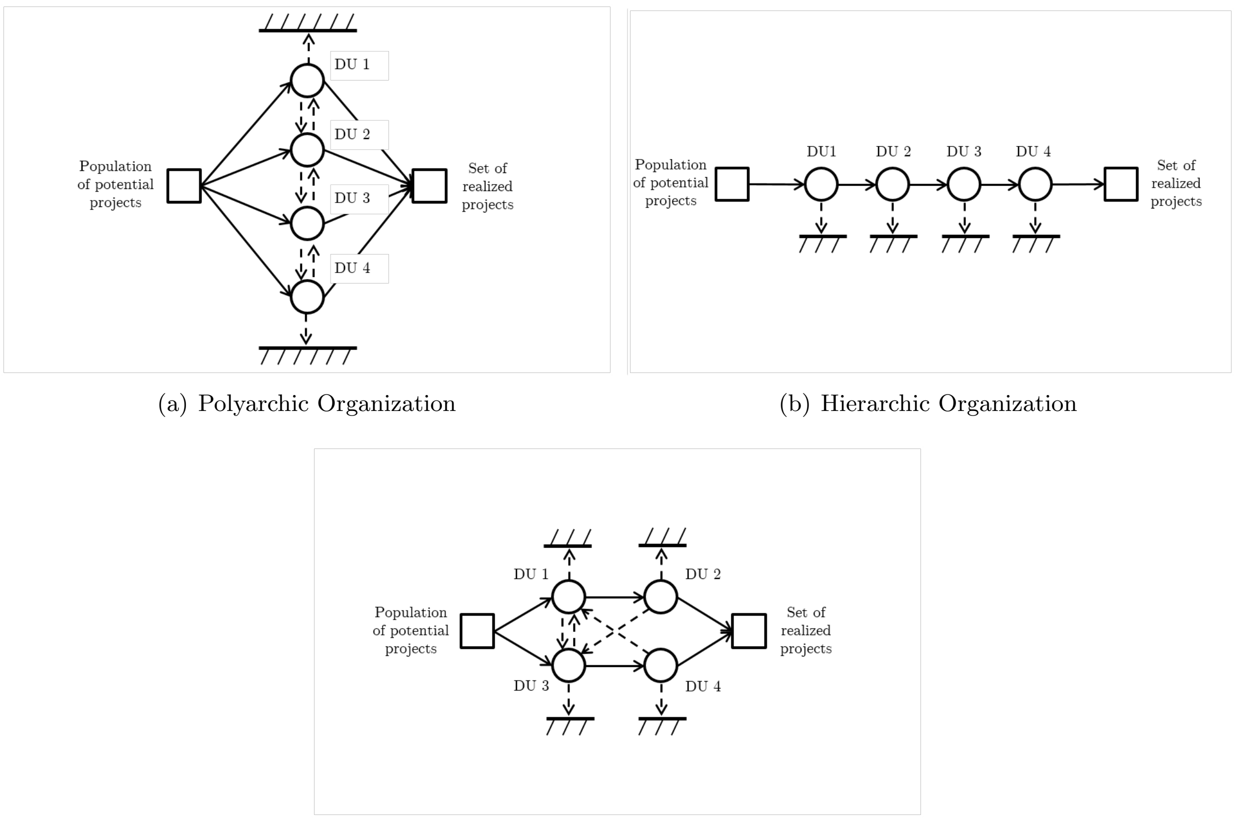
The evaluations of the decision units get aggregated to an organizational decision in step 4 of the model. This process depends on the organizational design. We aim to analyze polyarchies, hierarchies and mixed organizational forms. Sah and Stiglitz (1986) analyze organizations with only two decision units. While this allows the construction of polyarchies and hierarchies, there is no possibility to construct a mixed form. As such, we need a minimum of three units. For ease of interpretation, we further only want to consider symmetric organizational forms. This makes us analyze organizations with four decision units. If the organization arranges the decision unit as a polyarchy, the organization makes decisions in a decentralized manner such that a single positive evaluation by a decision unit is sufficient for a project to be realized. In case the project is evaluated negatively, another decision unit considers it until it is either evaluated positively by one of the units, or negatively by all of them. In the latter case it will be discarded. Given a probability of positive evaluation $p$, the polyarchy thus accepts a project into the set of realized projects with probability $f_P(p) = p + (1-p)p + (1-p)^2 p + (1-p)^3 p$. The polyarchic organization is displayed in panel (a) of Figure 2.

In the hierarchy, decisions are made in a centralized form. Projects thus require positive evaluation from all decision units to be accepted into the set of realized projects. A positive evaluation of the first decision unit leads to an evaluation by the second unit, a process that carries on until the fourth decision unit. If any of the units in the chain evaluate the project negatively, it is discarded. A project with positive evaluation probability $p$ is thus included into the set of realized projects with probability $f_H(p) = p^4$. The hierarchic organization is displayed in panel (b) of Figure 2.

The mixed structure is a combination of both extremes. This form can be thought of as a polyarchy made up from two hierarchies with two decision units each. It includes a project in the set of realized projects with probability $f_M(p) = p^2 + (1-p^2)p^2$ and is displayed in panel (c) of Figure 2.

The functions $f_i(p)$ with $i \in \{H, P, M\}$ are screening functions, or organizational designs, that convert evaluations by individual decision units into organizational decisions. Mathematically, the likelihood of a positive evaluation by an individual decision unit gets aggregated into the likelihood of the organization realizing this project. In our setup, different organization designs correspond to different screening functions. Clearly, all screening functions are increasing for $p \in [0, 1]$, that is,

*Figure 2* – Pictographic representation of the three analyzed organizational forms.




(a) Polyarchic Organization

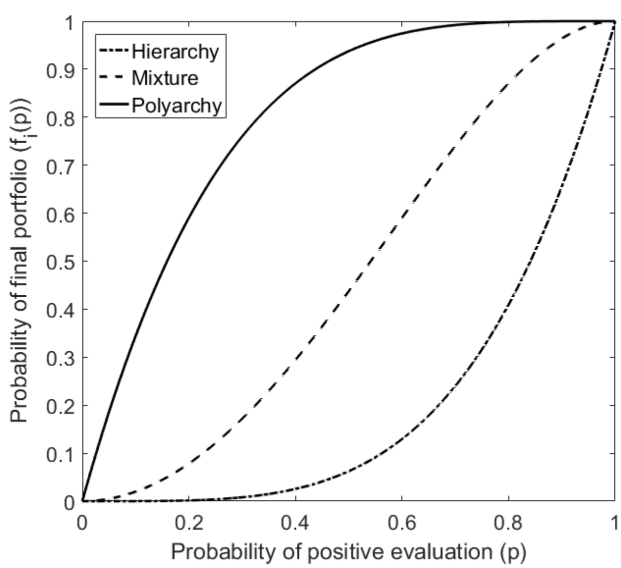
(b) Hierarchic Organization

(c) Mixed Organization

projects with a higher likelihood of being evaluated positively individually have a higher likelihood of being realized. Moreover, since all organizational forms include all projects which have a positive evaluation probability of 1 and include no projects with a positive evaluation probability of 0, the screening functions all have $f_i(0) = 0$ and $f_i(1) = 1$.

The three functions corresponding to different organizational designs are plotted in Figure 3. A polyarchic design has a concave screening function $f_P(p)$ that lies consistently above the 45 degree line. This means that the aggregate probability of realization is always higher than the likelihood of an individual positive evaluation (because the project gets multiple "draws") and that this effect is strongest for low $p$. Conversely, a hierarchy has a convex function $f_H(p)$ below the 45 degree line as a project has to be evaluated positively by multiple decision units simultaneously. This implies that low-probability projects are even less likely to be realized, while the likelihood of realization approaches the probability of a positive evaluation for higher $p$. Interestingly, the mixed design $f_M(p)$ resembles a hierarchy for low $p$ (it is convex) and a polyarchy for high $p$ (it is concave), with the inflection point of the function being at $1/\sqrt(3) \approx 0.58$. This implies that for projects with a low probability $p$ of being evaluated positively, the aggregate probability of realization is lower than $p$. Conversely, projects with a fairly high probability of an individual positive evaluation have an ever higher aggregate probability of realization. Also note that the functions do not intersect, so that for a given $R$ and a given initial portfolio of potential projects, polyarchies always realize the most projects, hierarchies the fewest, with mixed forms in between.

*Figure 3* – Screening functions of the three analyzed organizational forms.




In the last step of the model (step 5 in Figure1), the profit is realized. From the previous steps, we know that the positive evlaution of a project of type $t$ is dependent on the project's pay-off, the screening rule, and the noise of the signal such that we can write $p_t(x_t, R, \sigma)$. The evaluations of the decision units are aggregated by the screening function. As such the expected profit of a single project for organizational type $i$ can be written as

$$E[\pi_i] = \eta x_g f_i(p_g(x_g, R, \sigma)) + (1-\eta) x_b f_i(p_b(x_b, R, \sigma)) \tag{2}$$

The different organization designs determine how many and which kinds of projects the organization realizes. We can therefore compare the performance of the three organization designs using equation (2). We consider two cases. On the one hand, we investigate the situation in which the screening rule $R$ is given and cannot be changed (as is likely in the short run). On the other hand, we let $R$ be chosen endogenously by the organization to maximize profits *given* the organization design. We think of this latter case as the long run. Before we consider the individual cases, however, we will introduce two additional concepts, a quality index of the population of potential projects and the concept of discriminatory power.

### 2.2 Population Quality and Discriminatory Power

When considering equation (2), we can rearrange it, such that it reads $\frac{E[\pi_i]}{-(1-\eta)x_b} = \frac{-\eta x_g}{(1-\eta)x_b} f_i(p_g(x_g, R, \sigma)) - f_i(p_b(x_b, R, \sigma))$. Because $\eta$ and $x_b$ are exogenous parameters describing the environment, we can see that maximizing $\frac{E[\pi_i]}{-(1-\eta)x_b}$ renders equivalent choices to maximizing $E[\pi_i]$. When we further denote $\frac{-\eta x_g}{(1-\eta)x_b}$ as $\kappa$, we can see that organizational forms should be chosen to maximize

$$\kappa f_i(p_g(x_g, R, \sigma)) - f_i(p_b(x_b, R, \sigma)). \tag{3}$$

Here, $\kappa$ characterizes the population of potential projects. Large values of $\kappa$ can be caused by a large share of good products in the population or by high relative pay-offs of good projects in comparison to bad projects. $\kappa$ is thus a quality index for the population of potential projects.

From equation (3) we can see that in addition to $\kappa$, the shape of an organization's screening rule also impacts its performance. The screening function should be as low as possible at $p_b$ and as high as possible at $p_g$. This makes screening functions particularly attractive if they have a steep slope between (the possibly endogenously determined values of) $p_b$ and $p_g$. The slope of the screening function between the two probabilities can be seen as the discriminatory power that the organizational form has. It describes how sensitive an organization's decision to include a project into the set of realized projects is to a change of the project's probability of a positive evaluation by a single decision unit. Figure 3 and straightforward calculations show that the three organizational forms have the steepest parts of their screening functions at different points in the unit interval. $f_P$ is steepest at $p = 0$, $f_H$ is steepest at $p = 1$ and $f_M$ is steepest at $p = 1/\sqrt{3}$. It follows that the polyarchy is attractive when both $p_b$ and $p_g$ are low and the hierarchy is attractive if they are both high. The mixture forms is steepest for intermediate values of $p$ and is thus most likely to be the optimal organizational form if $p_b$ is below while $p_g$ is above the middle of the unit interval. The best fitting organizational form for a given environment is thus determined, in part, by the discriminatory power that each organizational form can offer in that environment. This is the first central result of the paper.

**Result 1.** Discriminatory power is an essential component when determining the optimal organizational design given a specific environment.

It is immediately obvious that the discriminatory power of an organization's screening function is important in the case $R$ (and thus $p_g$ and $p_b$) is exogenous. However, as is elaborated on in Section 2.4, the concept is also of central importance when $R$ can be set endogenously by the organization.

### 2.3 Exogenous and Identical Screening Rules

We now consider the situation in which the screening rule $R$ is exogenous and identical for all different organizational forms. In this case, $p_b$ and $p_g$ will also be identical for all forms. This is because organizations do not differ with regard to the individual decisions of their decision units, but only with regard to how these individual decisions are aggregated. The environment in which the organization operates is completely characterized by $\kappa$ (that is $x_b$, $x_g$ and $\eta$), $R$ and $\sigma$. When $\kappa$ is given, $R$ and $\sigma$ determine $p_b$ and $p_g$. Because $R$ and $\sigma$ are somewhat hard to interpret in an absolute sense, we will visualize environments by using $p_b$ and $p_g$ instead. This is possible, because varying $R$ and $\sigma$ allows us to reach any admissible combination $p_g > p_b$ for any value of $\kappa$.[1]

Using equation (2), we can then consider the profit of the individual organizational types directly. A comparison of two different organizational forms can then be given by the value $\Delta^{\pi}_{i,j} = E[\pi_i] - E[\pi_j]$. If it is positive, type $i$ is superior to type $j$ given the population of potential projects and the screening rule. From equation (3) we can see that $\Delta^{\pi}_{i,j} > 0$ is equivalent to

$$\kappa[f_i(p_g) - f_j(p_g)] > f_i(p_b) - f_j(p_b). \tag{4}$$

If an exogenous screening rule (in the form of $p_g$ and $p_b$) is taken as given, the quality index of the portfolio of potential projects, $\kappa$, is the only determining factor for the superior organizational form. Whether the population of potential projects is of a given quality due to the prevalence of good projects or the value of these projects is immaterial for the outcome.

The inequality in equation (4) highlights the trade-off inherent in choosing one organizational form over another. As is evident from Figure 3, the screening functions of the different organizational forms never cross. As a consequence, as long as $p_b$ and $p_g$ are exogenous, organizational forms can be ordered by the share of realized projects from the population of potential project. We can thus easily extend Proposition 1 of Sah and Stiglitz (1986) to three different organizational

[1] Consider $p_g - p_b = F(R - x_b, \sigma) - F(R - x_g, \sigma)$. Since $x_g$ is a constant, we relabel $R - x_g$ as $\varphi$. Consider the case $p_g < .5$, then for any value of $p_g \in (0, 0.5)$ and any value of $\sigma$, there is a value of $\varphi(\sigma)$ such that $p_g = 1 - F(\varphi(\sigma), \sigma)$. This follows from $F(0, \sigma) = 0.5$, $\lim_{a\to\infty} F(a, \sigma) = 0$ and the intermediate value theorem. Since $F(\varphi(\sigma), \sigma) = F(\varphi(\sigma)/\sigma, 1)$, it follows that $\varphi(\sigma)/\sigma = c$ has to be constant. When we now consider $p_g - p_b = F(c + (x_g - x_b)/\sigma, 1) - F(c, 1)$, we can see that $p_b = 1 - F(c + (x_g - x_b)/\sigma)$. Since $\lim_{a\to\infty} F(c + (x_g - x_b)/a, 1) = p_g$ and $\lim_{a\to 0} F(c + (x_g - x_b)/a, 1) = 1$, it follows that $p_b$ can take on any value in the open interval $(0, p_g)$. The proof for $p_g > .5$ is analogous. The case $p_g = .5$ is trivial.

forms. The selected number of projects is highest for the polyarchy and lowest for the hierarchy.[2] Between two organizational forms, one will thus always allow more good and more bad projects into the set of realized projects. Equation (4) implies that a more lenient organizational form $i$ is superior to a stricter form $j$ if the beneficial tendency to admit additional good projects, weighted by population quality indicator $\kappa$, outweighs the cost of admitting additional bad projects. Equation (4) also makes apparent that increasing values of $\kappa$ imply an increasing attraction of more lenient organizational forms, such as the polyarchy.

When $\kappa = 1$, the population of potential projects is balanced in its quality. That is, if all projects of the population were to be realized, the expected profit would be 0. In this case, only the discriminatory power of the organization between $p_b$ and $p_g$ is decisive as the optimal organizational form simply maximizes $f_i(p_g) - f_i(p_b)$. This case is shown for all admissible pairs of $p_b$ and $p_g$ in panel (a) of Figure 4.[3] As we know from the discussion of discriminatory power, the mixture form performs best when $p_b$ is below while $p_g$ is above the middle of the unit interval. Due to the slight asymmetry of $f_M(p)$, particularly screening rules with $p_b = 1/(\sqrt{3}-1) - 1/(\sqrt{3}-1)p_g$ (which is close to $p_b = 1 - p_g$) make the mixture form the best option. Because of the steepness of $f_M(p)$ and the relatively flat shapes of $f_H(p)$ and $f_P(p)$ in the area of $1/\sqrt{3}$ ($\approx 58\%$), any combination of $p_g$ and $p_b$ around the middle of the unit interval will lead the mixture form to be the best choice for the organization. However, if $p_g$ is particularly high and $p_b$ is particularly low, only small deviations from $p_b = 1/(\sqrt{3}-1) - 1/(\sqrt{3}-1)p_g$ are necessary to make another form superior. For example, if $p_g$ is relatively high and we set $p_b$ at a value smaller than $1/(\sqrt{3}-1) - 1/(\sqrt{3}-1)p_g$, the polyarchy will increase its performance the most because $f_P(p)$ has a high discriminatory power for low values of $p$. This discriminatory power will make the decrease in $p_b$ lead to the most additional exclusions of bad projects in the polyarchy among all organizational forms. This high number of exclusions of bad projects compensates for the errors of omission the polyarchy makes for good projects. A converse argument can be made for the hierarchy if $p_b$ is low and $p_g$ is set at a higher level than $1 - (\sqrt{3}-1)p_b$.[4]

**Result 2.** When the screening rule is exogenous and the portfolio of potential projects is balanced ($\kappa = 1$), mixture forms perform best when $p_b$ is below while $p_g$ is above the middle of the unit interval.

When the population of potential projects becomes skewed towards higher quality ($\kappa > 1$) or lower quality ($\kappa < 1$), the advantages of the mixture form become less pronounced. Examples for

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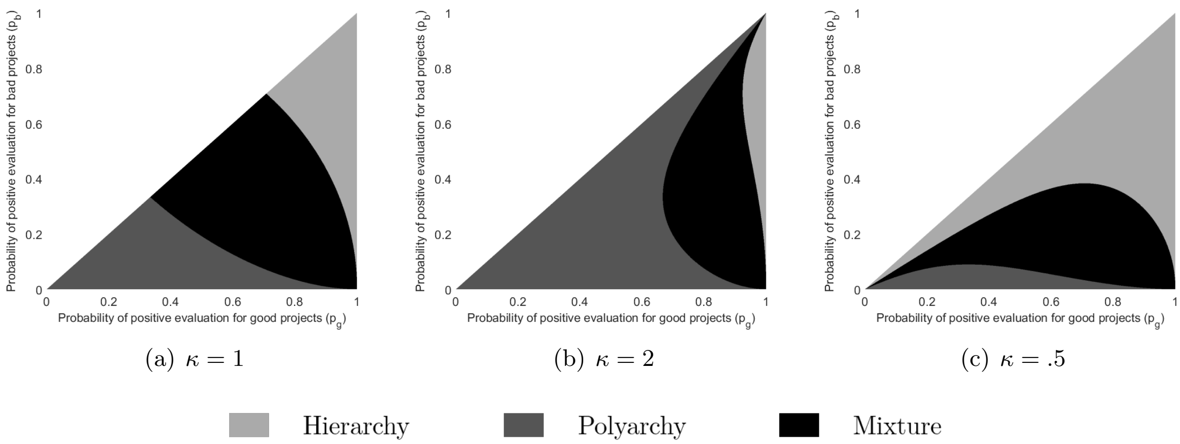
[2]To see this formally, note that $f_P(p) - f_M(p) = p + (1-p)p + (1-p)^2 p + (1-p)^3 p - p^2 - (1-p^2)p^2 = 4p(1-p)^2 > 0$ and that $f_M(p) - f_H(p) = p^2 + (1-p^2)p^2 - p^4 = 2p^2(1-p^2) > 0$.

[3]The reason why neither the graph in panel (a) of Figure 4 nor the graph in panel (a) of Figure 8 are completely symmetrical is that $f_M(p)$ is not fully symmetrical. Rather, the mixture form is slightly closer to the hierarchy than it is to the polyarchy in its behavior.

[4]Analytical solutions to describe the exact relationship between $p_g$ and $p_b$ at which one form becomes superior to the others exist. However, due to the high order of the considered polynomials in $f_i(\cdot)$, their solution becomes tedious without informing further than the numerical solutions presented in Figure 4.

*Figure 4* – Best performing organizational form when the scoring rule is exogenous and identical for all organizational forms.




these cases are given in panels (b) and (c) of Figure 4, respectively. In the former case, it becomes particularly important to realize as many good projects as possible, while the cost of realizing bad projects is lower in a relative sense. This makes the most loosely screening organizational form, the polyarchy, superior in most environments. However, the mixture form can still represent the best organizational design if the exogenous screening rule is unfavorable for the polyarchy (i.e., $p_g$ is relatively high). In this case, the fact that the steepest slope of $f_M(p)$ is at higher levels than that of $f_P(p)$ favors the mixture form despite its generally more restricted screening. Because the two screening functions move closer to each other as $p$ approaches 1 (as can be seen in Figure 3), the mixture form is now able to include almost as many good projects as the polyarchy. At the same time, the mixture form can exclude many of the bad projects that the polyarchy includes. In other words, when $p_g$ is high and both polyarchy and hierarchy are including most good projects, the number of excluded bad projects again becomes more important. When $p_g$ approaches one, this effect becomes so strong, that the hierarchy becomes the best organizational form.

A similar picture emerges if the population of potential projects is skewed towards bad projects and excluding these from the set of realized projects becomes most important. Here, the most restrictively screening organizational form, the hierarchy, is superior in most situations. However, when $p_b$ becomes small and the mixture form excludes almost the same amount of bad projects as the hierarchy, it again becomes important how many good projects are included which is why the mixture form (and in extreme cases the polyarchy) can again become optimal.

**Result 3.** When the screening rule is exogenous and the portfolio of potential projects is unbalanced ($\kappa < 1$ or $\kappa > 1$), polyarchies or hierarchies are generally advantageous except for the case where the exogenous screening rule favors one extreme form while the portfolio of potential projects favors the other.

Summarizing Results 2 and 3, the mixture form seems to be advantageous in situations in which a balanced approach to the selection process is required. This is either the case, if the exogenous screening rule leads to $p_b$ below the middle of the unit interval and $p_g$ above it or if the population of potential projects favors one extreme organizational form, while the exogenous screening rule favors the other. The former case resembles traditional investment problems in which both good and bad projects exist, such as investments in incremental efficiency enhancements of the production processes in a manufacturing firm. The latter case can, for example, exits when an organization that was originally intended (and instructed) for one purpose has to take on an entirely different task without the organizational guideline (i.e. the screening rule $R$) being sufficiently adjusted. An example from recent business practices would be the situation that large industrial organizations suddenly intend to act as corporate venture capitalist without sufficiently adjusting corporate culture.

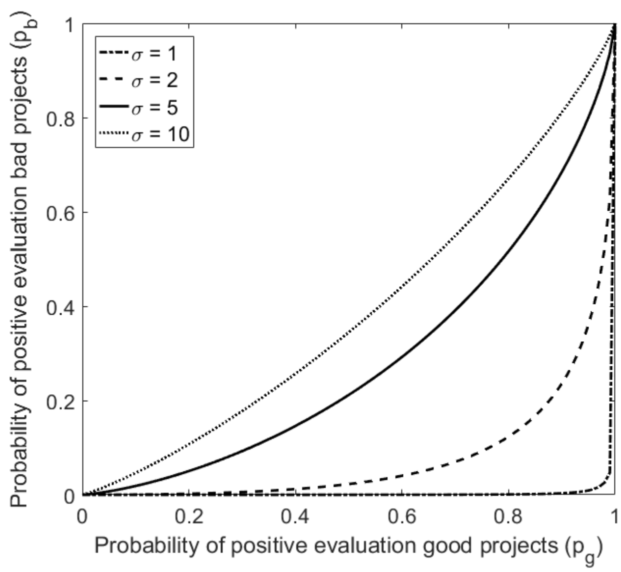
Because the advantage of the mixture form stems from having a steep screening function for intermediate probabilities, it appears to be unique to analyzing short-term behavior of organizational forms. One could assume that when long-term behavior is studied, the organizational forms can adjust their screening rule $R$ such that the steepest slope is always between $p_b$ and $p_g$ and that the mixture form thus loses its advantage. As we will see in the next section, this intuition is misleading. Even with endogenous screening rules, the position of the steepest part of the screening function is still important.

### 2.4 Endogenous Screening Rules

While it is not unrealistic that screening rules are exogenous and identical in the short term, organizations will clearly adapt their screening rule $R$ to the best possible value over time.[5] For each operational environment determined by $x_b$, $x_g$, $\sigma$ and $\eta$, the firm then chooses $R$ such that $\pi$ is maximized. From equation (2), we can see that this is equivalent to maximizing $E[\pi_i] = \kappa f_i(p_g(R)) - f_i(p_b(R))$. Thus, they maximize a weighted difference between including good projects and excluding bad projects. For the following discussion it is critical to note that setting $R$ does not allow organizations to choose the values for $p_b$ and $p_g$ freely. Choosing $R$ simultaneously determines $p_b$ and $p_g$. Both probabilities are decreasing in $R$, i.e. the probability of a positive evaluation of both types of projects decreases with more strict organizational guidelines on the evaluation. Since $R$ is the only parameter the organization can change, the two probabilities of positive evaluation thus have a predetermined relationship. By the normality assumption on our error term, this relationship can be described by $p_b = 1 - F\left(F^{-1}(1-p_g, 1) + \frac{x_g - x_b}{\sigma}, 1\right)$. We display this relationship for $x_g = 2$ and $x_b = -2$ and varying values of $\sigma$ in Figure 5. As explained above, higher levels of $p_g$ necessitate

[5] In this section, we depart from the model structure of Sah and Stiglitz (1986) since they assume a continuous population of projects. We opt for the binary structure because it is simpler and thus easier to grasp intuitively. Sah and Stiglitz (1986) also consider two types of polyarchies when the screening rule is endogenous: coordinated and uncoordinated organizations. Because we are interested in organizational design from a managerial perspective, we only consider coordinated polyarchies which, by definition, always have (weakly) higher profits than their uncoordinated counterparts.

*Figure 5* – Possible combinations of $p_g$ and $p_b$ due to varying $R$ for different values of $\sigma$. The figure is drawn for $x_g = 2$ and $x_b = -2$ such that the relative uncertainty in the market, $\frac{\sigma}{x_g - x_b}$, varies from 0.25 (for $\sigma = 1$) to 2.5 (for $\sigma = 10$).




higher values of $p_b$ – setting $R$ involves a trade-off between how many good projects the organization can acquire and how many bad projects it must tolerate. Intuitively, this is appealing. When giving central guidelines about evaluating projects, organizations can communicate strictness or leniency in the evaluation process. Strictness (high $R$) will lead to fewer bad projects but has the side effect of fewer good projects, as well. Similarly, leniency (low $R$) will lead to more good projects at the expense of more bad projects.

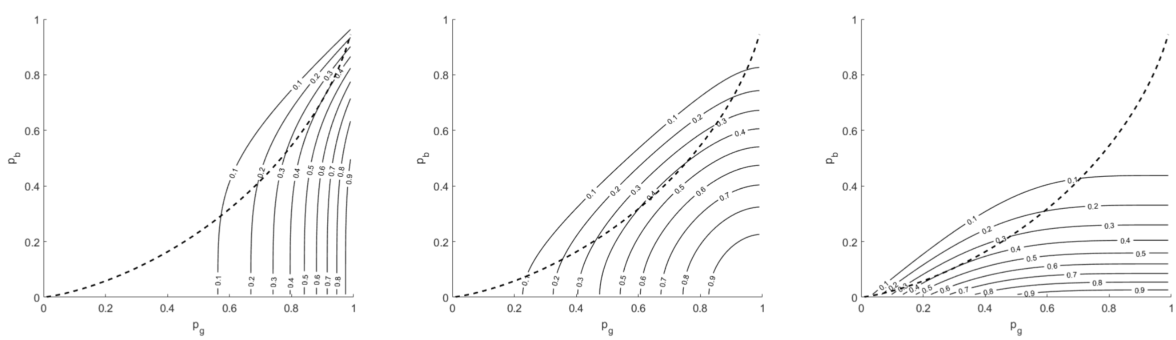
A second important property of the $p_b(p_g)$ functions displayed in Figure 5 is that they are convex and symmetric along the 45 degree line described by $p_b = 1 - p_g$. As a consequence, $p_g - p_b(p_g)$ is maximized at $p_b = 1 - p_g$. The biggest difference between the two probabilities can be achieved when $p_g$ lies above 0.5 while $p_b$ lies below it. This is intuitive. If one pictures the probability distributions of the signals $s$ for good projects and bad projects as two normal distributions with equal standard deviation and different means, than the biggest difference between $p_g = 1 - F(R - x_g, \sigma)$ and $p_b = 1 - F(R - x_b, \sigma)$ will result from setting the screening rule in the middle between the two means, that is $R = (x_g + x_b)/2$.[6] When $R$ is set to a different value such that one deviates from $p_b = 1 - p_g$, the difference between the two probabilities of positive evaluation declines. This decline is strong, if the standard deviation of the signal relative to the difference in project payoffs is low (that is organizations operate in an environment with little uncertainty). Once $\sigma$ increases, the

[6] We maximize $p_g - p_b = F(R - x_b, \sigma) - F(R - x_g, \sigma)$ by setting $\phi(R - x_b, \sigma) = \phi R - x_g, \sigma$ with $\phi(y, \sigma)$ being the pdf of a normal distribution with mean 0 and standard deviation $\sigma$. Given symmetry of the normal distribution around the origin, this equation has two solutions, $R - x_b = R - x_g$ and $R - x_b = x_g - R$ only the latter of which is feasible. Rearranging renders $R = (x_g + x_b)/2$.

effect of deviating $R$ from $(x_g + x_b)/2$ becomes less pronounced *ceteris paribus*.

Given the aforementioned restrictions on the relationship of $p_b$ and $p_g$, the different organizational forms set $R$ such that their profit is maximized. This can be seen as a typical optimization problem under a budget constraint. For each $(p_g, p_b)$ pair, an organizational form realizes expected profit $E[\pi_i(p_g, p_b)]$. The firms thus have iso-expected-profit curves in the $p_g$-$p_b$-plane, which are displayed for a neutral population of potential projects ($\kappa = 1$) in Figure 6. The organizational forms treat $p_b(p_g)$ as a budget constraint the highest iso-expected-profit line that is tangential to it. This is exemplified for the case of $\sigma = 5.5$ in Figure 6. While the organizations can influence their screening rule, they cannot change the screening function for the overall evaluation of the projects. The difference in screening functions leads to different shapes of the iso-expected-profit lines in Figure 6 and thus to different profit maximizing tangential points which in fact are different profit maximizing values of $R$. This process is shown for $x_g = 2$, $x_b = -2$, $\eta = 0.5$ and $\sigma = 5$ in Figure 7.

*Figure 6* – Iso-profit lines of the different organizational forms in the $p_g$-$p_b$-plane for $\kappa = 1$.




(a) Hierarchy (b) Mixture (c) Polyarchy

Since for any value of $R$ in a given environment, the polyarchy includes the most projects while the hierarchy includes the least, intuition would dictate that polyarchies have the strictest screening rules, while hierarchies have the most lenient. Indeed, a formal extension of proposition 4 in Sah and Stiglitz (1986) shows that the optimal screening rules for each organizational form can be described by $R^P > R^M > R^H$.[7] This can also be seen from the shapes of the iso-expected-profit

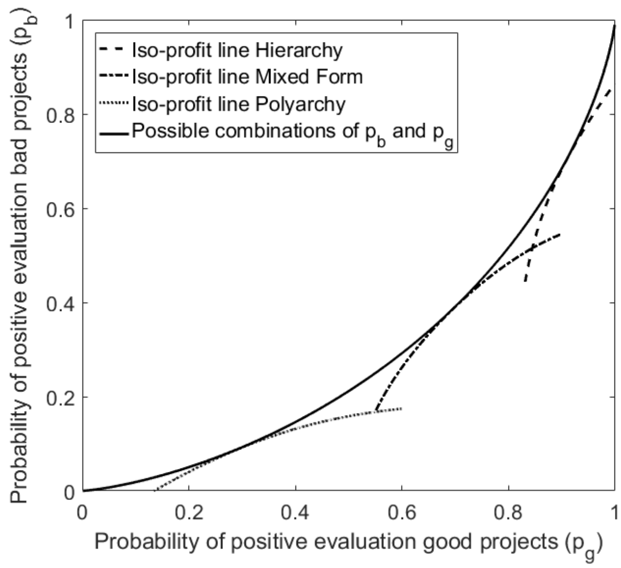
[7] Organizational forms maximize by setting $R$ according to $\text{argmax}_R\{\eta x_g f_i(p(R, x_g)) - (1-\eta) x_b f_i(p(R, x_b))\}$. We define $c(x) = \frac{p(x) - p(x)^3}{p(x)^3}$ and note that $c(0)E[\pi_H(R)]$ has the same global maxima as $E[\pi_H(R)]$ because $c(0)$ is a constant. We the see that

$$\frac{\partial c(0)E[\pi_H] - E[\pi_M]}{\partial R} = 4\left[\eta x_g p(R, x_g)^3 \frac{\partial p(R, x_g)}{\partial R}(c(0) - c(x_g)) + (1-\eta) x_b p(R, x_b)^3 \frac{\partial p(R, x_b)}{\partial R}(c(0) - c(x_b))\right] < 0$$

because $\frac{\partial p(R,x)}{\partial R} < 0$ and $\frac{\partial c(x)}{\partial x} = \frac{-2\frac{\partial p(x)}{\partial x}}{p(x)^2} < 0$. From this, we see that $c(0)\frac{\partial E[\pi_H]}{\partial R} < \frac{\partial E[\pi_M]}{\partial R}$.

Proof proceeds by contradiction. Assume that $R^H > R^M$, then from the above, we know that $E[\pi_M(R^H)] - E[\pi_M(R^M)] > c(0)[E[\pi_H(R^H)] - E[\pi_H(R^M)]]$. However, the left term is negative, while the right term is positive and thus we have a contradiction, concluding the proof for $R^H < R^M$.

*Figure 7* – Optimal values of $p_g$ and $p_b$ (and thus $R$) for the three organizational forms. The figure is drawn for $x_g = 2$ and $x_b = -2$, $\eta = 0.5$ and $\sigma = 5$.




curves in Figure 6 and the exemplified solution in Figure 7.

We now consider the choice of the optimal organizational form, given an environment characterized by a population of quality $\kappa$ and a relative uncertainty $\frac{\sigma}{x_g - x_b}$ which describes the size of the error component in proportion to the difference in the quality signals of project types. The value of $\kappa$ determines the relative importance of realizing good projects and excluding bad ones. As is described above, the relative uncertainty determines how much the difference between $p_g$ and $p_b$ is increased by choosing a screening rule in the middle of the two possible pay-offs. As with exogenous screening rules, not the absolute difference between $p_g$ and $p_b$, but the discriminatory power of the screening function between the two probabilities is decisive for the maximizing profits. This implies an inherent advantage of the mixture form when considering endogenous screening rules: both the difference of $p_g$ and $p_b$ and the discriminatory power of the screening function between $p_g$ and $p_b$ is highest when $R$ is chosen towards the middle of $x_g$ and $x_b$. Even though optimal screening rules for maximizing $p_g - p_b$ and $f_M(p_g) - f_M(p_b)$ do not fully coincide (the former is maximized at $p_b = 1 - p_g$ while the latter is maximized at $p_b = 1/(\sqrt{3} - 1) - 1/(\sqrt{3} - 1)p_g$), they are still closer than in the other organizational forms. Thus, as long as the population of potential projects is approximately[8] balanced, the mixture form will perform best among the three possible forms.

**Result 4.** When the screening rule is endogenous and the population of potential projects is

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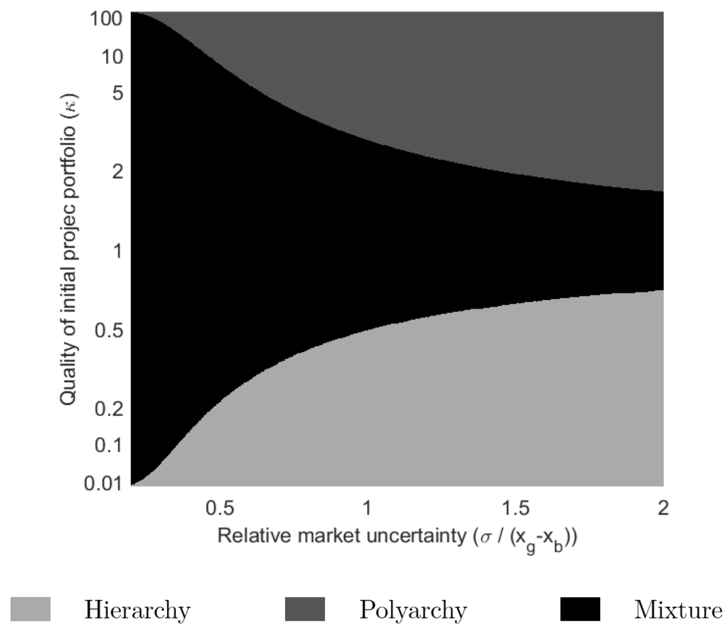
To show $R^P > R^M$, we proceed analogously, using $c(x) = \frac{1-3p(x)+3p(x)^2-p(x)^3}{p(x)-p(x)^3}$. $\frac{\partial c(x)}{\partial x} = \frac{\partial p(x,R)}{\partial x} \frac{6p(x)^2-8p(x)^3+3p(x)^4-1}{(p(x)-p(x)^3)^2} < 0$, because $6p(x)^2 - 8p(x)^3 + 3p(x)^4 \leq 1$ for $x \in [0, 1]$.

[8]Because $1/\sqrt{3} \approx 0.58$, the best population of potential projects for the mixture form is slightly skewed towards better projects.

*Figure 8* – Best performing organizational form when the scoring rule $R$ can be chosen endogenously by the organization and is not necessarily identical for all organizational forms. The figure is drawn for $x_g - x_b = 5$ with $\kappa$ being varied through varying $\eta$.




approximately balanced, the mixture form will be the best performing organizational form.

The inherent advantage of the mixture form becomes less prevalent when the population of potential projects becomes unbalanced. This can be seen in Figure 8. When $\kappa$ is around 1, the mixture form performs best. As the population becomes unbalanced, the asymmetric shapes of the other forms' screening functions again become advantageous. The hierarchy still has a convex screening function and the polyarchy has a concave one. This implies that the hierarchy will always aim more at minimizing the amount of bad projects than at maximizing the amount of good projects. The polyarchy has the reverse approach. Thus, if the population of potential projects is unbalanced and one of these two approaches is more advantageous, the mixture form might not be optimal any more.

Exactly how unbalanced the population must be for one or the other form to be better, depends on the uncertainty in the environment. Low uncertainty in the evaluation of projects leads to a more strongly curved function $p_b(p_g)$. The difference between $p_g$ and $p_b$ can thus be increased more strongly when choosing $R$ towards the middle of $x_b$ and $x_g$. This makes the inherent advantage of the mixture form particularly pronounced. For low values of $\sigma$ relative to $x_g - x_b$, the population of potential projects must thus be strongly unbalanced for the mixture form not to be optimal. If the relative uncertainty in the environment is high, smaller deviations from a balanced population are sufficient for a different form to be optimal. The uncertainty in the evaluation of projects thus acts as a mediator for the influence of $\kappa$ on the relative performance of the mixture form.

**Result 5.** When the screening rule is endogenous and the population of potential projects is unbalanced, ($\kappa < 1$ or $\kappa > 1$), the polyarchy or the hierarchy can become the best performing organizational form. The mixture form is most resilient towards changes in $\kappa$ when the relative market uncertainty is low.

## 3 Discussion and Implications for Management Practices

- Mixed form is sometimes optimal, actually in a surprising number of cases.
- This is not necessarily only because it provides a middle ground between the hierarchy and the polyarchy,
  - On the one hand it does provide a middle path, which, for example, makes it attractive if the (exogenous) screening rule is very fit for one environment but the firms are operating in the opposite environment.
  - On the other hand, it has some own inherent advantages which the other two do not posses (technically: steepest slope of $f$ not at the boundary of the unit interval). This is not immediately apparent from Sah and Stiglitz (1986), because a mixture of both forms could have had an inverse-s shaped $f$ instead of an s-shaped one, which would not have provided this advantage.
- Decreasing the uncertainty in the evaluation of future projects increases the chance of the mixture form being optimal $\Rightarrow$ application to machine learning
- Even if the mixture form is not optimal in the current environment, it might be advantageous to choose it, because it might proof to be more robust to changes in the environment to which the screening rule / orgganizational guidelines are not adjusted immediately.
- Now are there examples of such forms? Almost everywhere!

## 4 Conclusions

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## Appendix A Glossary of the model

*Table A.1* – Glossary of notation with intuitive explanation

| Notation | Explanation |
|---|---|
| $\eta$ | Share of good projects in the population of potential projects. |
| $x_t$ | Pay-off from accepting a project of type $t$ into the organization's set of realized projects. |
| $s$ | Quality signal of a project observed by a decision-maker within an organization. Decision whether to give a positive evaluation of a project depends on whether this signal is larger or smaller than the organization wide screening rule $R$. Consists of the true quality of the project ($x_t$) and a random error component $\varepsilon$. |
| $\varepsilon$ | Idiosyncratic error term in a project's quality signal for each decision-maker within an organization. Represents the uncertainty a decision-maker feels about the quality of a project while evaluating. Distributed normally with zero mean and variance $\sigma$. |
| $R$ | The screening rule is the organizational guideline for decision-makers regarding their evaluation. Larger values lead to stricter evaluations. Is seen as a long-term strategy lever of an organization. |
| $p_t$ | Probability of a positive evaluation of a project of type $t$ by a single decision unit within an organization. Depends on quality signal of the project and the organizational guideline $R$. |
| $f_i(p_t)$ | Screening function of organizational form $i$. Renders a probability of accepting a project of type $t$ from the population of potential projects into the set of realized projects. |
| $E[\pi_i]$ | Expected profit due to a single project from the population of potential projects for an organization of type $i$. |
| $f_i(p_g) - f_i(p_b)$ | Discriminatory power of an organization $i$'s screening function between good and bad projects with probability of a positive evaluation $p_g$ and $p_b$. |
| $\frac{\sigma}{x_g - x_b}$ | Relative measure of the uncertainty in the market. |
| $\kappa$ | Quality indicator of the projects in the population of potential projects. Is always positive and larger values indicate a better population. $\kappa = 1$ can be seen as a neutral population where expected benefits of good project equal expected costs of bad projects when all projects are accepted. |