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Competing Screening Rules

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COMPETING SCREENING RULES

Abstract

Various studies show that agricultural cooperatives behave differently than their investor-owned counterparts. One explanation may be that the internal decision making process differs in these two governance structures. A model is developed to explore how endogenous screening rules affect efficient organizational choices and industrial structures. It is shown that screening level choice may outweigh architecture choice and that screening rules are strategic substitutes. Conditions are derived under which cooperatives are efficient organizational forms. It is also shown that competition may increase the attractiveness of investor-owned firms and circumstances are determined in which cooperatives and investor owned firms coexist in equilibrium.

Keywords

Architecture, screening, cooperatives, duopoly

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1 Introduction

Cooperatives and investor-owned firms (IOFs) are alternative forms of business organizations that buy, sell, and produce goods and services. Various studies show that cooperatives behave differently than their investor owned counterparts (Van der Krogt, 2002 and Van Oijen and Hendrikse, 2002). However, it is not well understood why these two organizations behave differently.

Another observation is that cooperatives and IOFs coexist in many markets. Hendrikse reports that both cooperatives and investor owned firms are observed in many European agricultural markets, e.g. pork, beef, poultry, eggs, milk, sugar-beet, grain, fruit, vegetables (1988). Similarly, Carriquiry and Babcock (2004) report for the USA that this coexistence is observed in the markets for hogs, corn, soybeans, wheat, and cattle. Various studies show that cooperatives have a number of advantages and disadvantages compared to IOFs (Vitaliano, 1983; Cook, 1995). From the perspective of governance structure, an obvious disadvantage of a cooperative is that it faces restrictions to issue claims against the residual profits of the organization. It is not listed in the stock market, which implies that cooperatives must finance investments through internally generated funds and debt, rather than issuing common stock. It also entails that cooperatives have less freedom to design incentive compensation schemes to motivate managers. The absence of a stock listing implies that equity-based compensation cannot be used and that there is no active takeover market replacing poorly performing managers. However, cooperatives exist in many industries. So, there must be advantages of adopting a cooperative.

It is well known that the board of directors in a cooperative is different from that of IOFs (Vitaliano, 1983; Hendrikse, 1989). We claim in this paper that the difference in the board of directors lead to different internal decision making structure, which in turn leads to different performance and competitive advantage. According to the agency theory, the decision process can be separated to two compound components of decision management (i.e., the initiation and implementation of decisions) and decision control (i.e., the ratification and monitoring of decisions) (Fama and Jensen, 1983). For modern firms including both IOFs and cooperatives, such separation of decision process is common. Normally, residual claimants retain approval rights by vote on the decisions such as membership, mergers, and auditor choice, and delegate most decision control rights to the board of directors. The board then delegates some decision control functions and most decision management functions to top management. In this case, sufficient board monitoring is necessary to guarantee the efficiency of firms. We claim more board monitoring is expected in cooperatives than in IOFs. For IOFs, the board normally includes insider (i.e. top management members) (Fama and Jensen, 1983), and in some case, top management even elects the board of directors. In contrast, the board in cooperatives are elected by and chosen from member-owners. Board monitoring is a public good. However, more active member participation in board monitoring is expected in cooperatives due to the substantial financial stake in the cooperative by the members (Hendrikse and Veerman, 2001b). Thus, the board in cooperatives has more incentives, on behalf of member-owners, to screen investment proposals initiated by the management, while the board in IOFs are easily subject to collusions with top management and t less motivated in screening investment projects. This can be justified by the following statement from the USDA (2002, p11).

'In an investor-owned firm, the chief executive officer (CEO) often has a large, if not dominant voice, in selecting the board of directors. Strong CEOs look for persons who share their vision for the future of the company and respect their managerial ability in selecting directors. When a new CEO takes over, directors who don't share his or her views are often encouraged to relinquish their seats on the board. This places the manager in a position of strong control over both setting and implementing company policy. In a cooperative, the CEO usually has significantly less influence over who sits on the board. Incumbent directors may have outlasted several managerial changes. When a board seat opens up, the influence of the CEO in the selection of the new director varies greatly depending on the culture of the association. Some cooperatives look for guidance from the manager, others deeply resent any involvement by the manager. As a result, directors often don't feel beholden to the manager for their position and have the independence, if they choose to exercise it, to question management decisions and reject its recommendations.'

This difference on board of directors has important implication on firms' decision making structure. For IOFs, the board of directors is less motivated in screening project proposals and

therefore real authority regarding accepting investment proposals mainly resides with top managers who initiate and implement investment projects. For cooperatives, the board of directors is actively involved in screening investment proposals and therefore real authority regarding accepting investment proposals mainly reside with the board. Hence, when screening an investment project, IOFs mainly adopt one level screening by top management who have power of decision management, while cooperatives mainly use two-level screening by both the board of directors who have power of decision control and top management with power of decision management. Figure 1 captures this difference. Dual screening may provide competitive advantage to cooperatives. In this paper, we will address this issue: how different screening influence behaviour and performance of cooperatives and IOFs.

Sah and Stiglitz (1986) cast lights on how different screening structures influence performance of economic systems and economic organizations. economic systems and organizations can be viewed as a collection of decision-making units. The term of ‘architecture’ is adopted to describe how multiple decision-making units are structured together to efficiently accept and reject investment projects in different economic systems and organizations. Individual units’ judgement entails errors. The architecture of an economic system matters, because it affects both the errors made by individuals within the system and how those errors are aggregated at the system level. One main conclusion is that the polyarchy architecture (i.e. an organization accepts an investment project when any individual unit accepts it) is prone to accept more investment projects than the hierarchy architecture (i.e. an organization accepts an investment project when no individual unit rejects it). To compensate for it, individual units in a polyarchy architecture are more conservative in screening than his counterparts in a hierarchy architecture.

Hendrikse (1989) further specifies the above analysis in the situation of cooperatives versus IOFs. It is found that a cooperative is distinguish by two decision-making units with veto power (that is, the General Assembly together with the Board of Directors forming one unit and the management at the processing stage of production) and an investor-owned firm is characterized by one decision unit. An investor owned firm accepts more projects than a cooperative, and a cooperative is desirable when type-II errors (that is bad projects are accepted) are relatively expensive. It is also shown that cooperatives become more attractive when the intensity of competition increases. However, the model provided by Hendrikse (1989) adopts exogenous screening, that is, it is assumed that, at individual decision making unit level, the probability of accepting good projects is always larger than the probability of accepting bad projects, and the probability of accepting good projects at individual unit level is the same for any architecture form. We will address the endogenous screening rules in this paper, i.e. each individual decision-making unit chooses its acceptance/rejection probabilities.

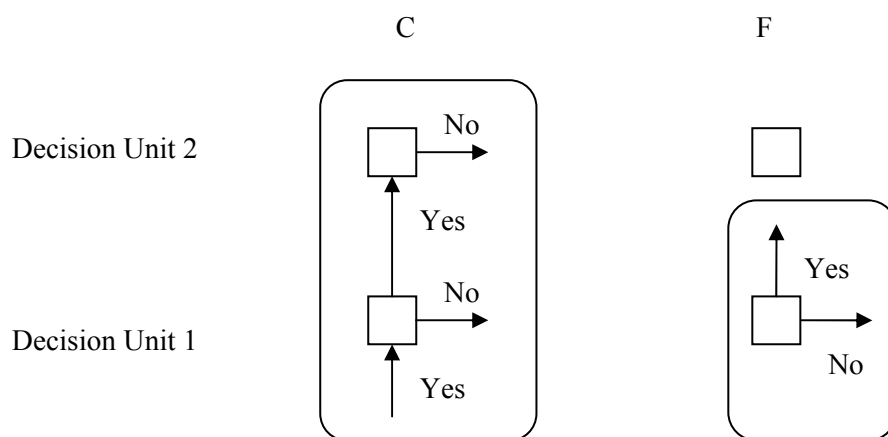


Figure 1 Investment Screening: Cooperative (C) versus Investor Owned Firm (F)

The objective of this paper is to examine how the endogenous screening rules affect behaviour and performance of investor-owned firms and cooperatives. We find that the cooperative chooses the lower screening level to compensate for its centralized decision-making structure, and the impact of

screening level choice may outweigh that of architecture choice. It implies that cooperatives are inclined to accept more projects if the screening is endogenous. Cooperatives and investor-owned firms can coexist under some circumstances, however, as competition increases, the attractiveness of investor owned firms raise accordingly.

The paper is organized as follows. In section 2, we present the model and analyze the monopoly case. Section 3 extends the model to the duopoly case. Section 4 formulates a summary and indicates some paths for further research.

2 The Model

Our model consists of a four stage game, where we consider a monopoly as well as a duopoly. The first stage consists of the choice of architecture. Architecture choices are made simultaneously and independently when there is a duopoly. Screening levels are chosen in the second stage of the game. In the third stage, nature chooses the type of project. Finally, project acceptance decisions are made by the organization(s). Again, if there is a duopoly, then acceptance decisions are made simultaneously and independently.

The monopoly case will be analyzed first. Define x as the net benefit of a project, where $x = V$ with probability α and $x = -W$ with probability $1 - \alpha$. Assume that the project evaluator observes $y = x + \theta$, where θ is distributed independently of x . Denote the density function of θ by $m(\theta)$ and its distribution function by $M(\theta)$. It is assumed that θ has a uniform distribution $U(-\phi, \phi)$. Imperfect screening is captured by assuming that $V - \phi < -W + \phi$, i.e. $V + W < 2\phi$. Project evaluators use reservation screening levels for screening: a project is accepted if its observed profit is above the reservation level, S , and is rejected otherwise. The screening function is defined as the probability that a project is judged to be good. It depends on its quality x and the screening level S , i.e. the screening function is $p(x, S) = \text{Prob}[y \geq S] = 1 - M(S - x)$.

Notice that the expected payoff maximizing screening level of an architecture will never be set lower than $V - \phi$ or higher than $-W + \phi$. It will never be set lower than $V - \phi$ because that will only increase the probability of accepting bad projects, i.e. increasing the number of type II errors, while screening levels higher than $-W + \phi$ will only increase the probability of rejecting good projects, i.e. increasing the number of type I errors. The expected payoff maximizing screening level of an architecture will therefore be in the interval $[V - \phi, -W + \phi]$.

Backward induction will be used as solution method, i.e. the screening level will be determined first as a function of the choice of architecture, and subsequently the choice of architecture is determined.

Stage 2: Determination of the payoff maximizing S of architecture I

Consider a cooperative with bureau i and bureau j . Bureau i choose S^i in order to maximize

$$\begin{aligned} & \alpha V \frac{V + \phi - S^i}{2\phi} p(V, S^j) - (1 - \alpha)W \frac{-W + \phi - S^i}{2\phi} p(-W, S^j) \\ &= \left\{ \frac{(1 - \alpha)W p(-W, S^j)}{2\phi} - \frac{\alpha V p(V, S^j)}{2\phi} \right\} S^i \\ &+ \frac{\alpha V(V + \phi) p(V, S^j)}{2\phi} - \frac{(1 - \alpha)W(-W + \phi) p(-W, S^j)}{2\phi} . \end{aligned}$$

This is a linear function. It implies that either $V - \phi$ or $-W + \phi$ is an expected payoff maximizing screening level. It reflects the result that the expected payoff maximizing screening level increases when either W becomes large or V becomes small. Notice that the screening level will be high, i.e. $-W + \phi$, when W is much larger than V . Similarly, the screening level will be low, i.e. $V - \phi$, when V is

much larger than W .¹ It can be shown the same conclusion holds for an investor-owned firm. The reason lying behind is quite simple. An organization, whatever its architecture is, will set up loose screening if it expects good projects to bring great return and therefore it is desirable to accept more projects. Figure 2 presents the payoff maximizing screening level choice as a function of V and W for each architecture, given the level of α . There is a set of values of V and W where S^C is low and S^F is high. This captures that a cooperative will adjust the screening level S downwards due to its tendency to commit many type I errors, while an investor-owned firm will adjust the screening level upwards due to its tendency to commit many type II errors.

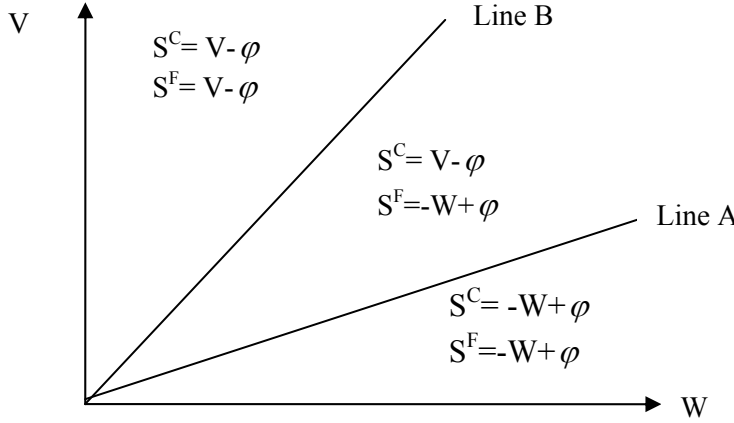


Figure 2 Expected payoff maximizing screening level of a cooperative and an investor-owned firm, for a given level of α

Stage 1: Determining the payoff maximizing architecture choice

The expected payoff maximizing architecture choice has to be determined for each value of V and W , given the level of α . If the value of W are so high that both organizations choose tight screening, that is, the expected payoff maximizing screening level choice is $-W + \phi$, then the investor-owned firm is preferred to a cooperative. The reason is straightforward. In this case, $p(V, -W + \phi) < 1$ and $p(-W, -W + \phi) = 0$, which entails that there are type I errors (i.e. $1 - p(V, -W + \phi) > 0$) and no type II errors. The investor-owned firm performs better because it is good at preventing type I errors. Similarly, a cooperative is chosen as the expected payoff maximizing architecture when both organizations choose loose screening (that is $V - \phi$). The loose screening choice of $V - \phi$ entails that $p(V, V - \phi) = 1$ and $p(-W, V - \phi) > 0$, which implies that there are only type II errors.

It is interesting to note that a cooperative is chosen as the payoff maximizing architecture when the values of V and W fall into the intermediate region between Line A and Line B.² Figure 3 summarizes the results regarding the payoff maximizing architecture choice by a monopolist.

Notice that this result is in line with Sah and Stiglitz (1986). Regarding screening levels, the investor-owned firm as a decentralized architecture is more conservative than the cooperative. The cooperative knows that this architecture choice rejects a lot of projects, i.e. commits a relative large amount of type-I errors. It responds by choosing a lower screening level (i.e. higher acceptance probability) to compensate for its cumbersome decision-making process. However, these results are not robust with respect to the exogeneity/endogeneity of screening level choice. Hendrikse (1998) points out that an investor-owned firm is inclined to accept more projects than a cooperative given the screening level is exogenous. What's more, the comparative static studies show that the attractiveness

¹ The mathematics is in the appendix 1.

² A cooperative is preferred to an investor-owned firm because Y_C is larger than Y_F , where $Y_C = \alpha V - (1 - \alpha)W[1 - (V + W)/2\phi]^2$ and $Y_F = \alpha V - (1 - \alpha)W[1 - (V + W)/2\phi]$.

of an investor-owned firm will raise, if the value of a good (bad) project increase (decrease), or the quality of the project portfolio proves improves. However, these conclusions are reversed when screening rules become endogenous.

The results entail that the impact of the screening level choice is more powerful than that of the architecture choice.

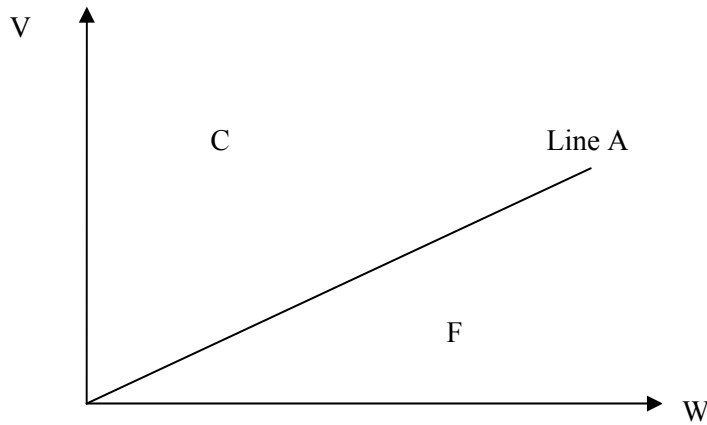


Figure 3 Payoff-Maximizing Architecture Choice by a Monopolist

3 Duopoly

The duopoly case involves two values for the acceptance of a good project. The decision whether the market has to be shared or not depends on a rival. We assume that the gains associated with a good project are split equally between the two firms when both organizations accept the project, and the loss associated with accepting a bad project is independent of market structure. The intensity of competition is captured by $\beta \in [0, 0.5]$. For example, if the intensity of competition is very intense, like Bertrand competition in a market with homogeneous products and unlimited capacity, then $\beta=0$. Sharing the market in a situation with a cartel is captured by $\beta=0.5$. Table 1-A and Table 1-B summarize these assumptions and reflect the payoff of the two organizations in the duopoly case. Notice that only payoffs of good projects are affected in the duopoly case. When a firm accepts a good project while its rival rejects it, the firm can capture all the gains associated with the good project. When both firms accept the project, they have to share the gains.

Firm i \ Firm j	A	R
A	$(\beta V, \beta V)$	$(V, 0)$
R	$(0, V)$	$(0, 0)$

Table 1-A: Duopoly payoffs when the project is good

Firm j \ Firm i	A	R
A	$(-W, -W)$	$(-W, 0)$
R	$(0, -W)$	$(0, 0)$

Table 1-B: Duopoly payoffs when the project is bad

Stage 2: Expected payoff maximizing screening levels

In duopoly situation, each organization tries to maximize its expected payoff by taking its competitor's action into consideration. For each organization, we distinguish four possible cases, that is, an investor-owned firm facing an investor-owned firm (FF), an investor-owned firm facing a cooperative (FC), a cooperative facing an investor-owned firm (CF), and a cooperative facing a cooperative (CC). In each case, organization i will choose its optimum screening levels depending on each possible choice of organization j , which gives the reaction function of architecture i . Appendix 2 shows how each organization reacts to its competitor in the above four cases. Figure 4 summarizes the results.

Notice that the slope of the reaction function (Fudenberg and Tirole, 1984) of organization i is piecewise vertical. There is a discontinuity in the reaction function of organization i at an intermediate level of the screening level of its competitor. Organization i will keep choosing loose screening (i.e., low screening level) when its competitor's screening levels are high enough; as its competitor reduces its screening level, the organization will stick to its loose screening until the competitor's screening level is reduced to be lower than a certain level. At that point, the organization will adjust its screening level upward. In sum, an organization will never reduce its screening levels when its competitor reduces its screening levels. It implies that screening levels are strategic substitutes (Fudenberg and Tirole, 1984).

The economic reason behind is obvious. Very tight/loose screening from the competitor does not change the expectation of organization i and thus does not influence the behaviour of organization i . For example, if the competitor takes such tight screening that it almost reject all projects, organization i will act as in monopoly case and thus choose its tight or loose screening depending on the values and composition of projects. If the competitor takes such loose screening that it almost accepts all projects, organization i will still act as in monopoly case except that the fact that it shares the benefits from good projects with its competitor. Only when the competitor takes a screening level that is low enough to take most good projects, may organization i adjust its screening level upward accordingly. In that case, if organization i sticks to its screening level, then the benefits from accepting good projects may so sharply reduced that the loss from accepting bad projects may overweight possible benefits from good projects.

The crucial value for the discontinuity point depends on the choice of architecture of both organizations. Appendix 6 shows that how the value is determined in four cases (i.e., FF, FC, CC, CF). Figure 5 summarizes the results and depicts that how architecture choices may influence the sensitivity of organizations.

Notice that the discontinuity point for an organization facing the competition from an investor-owned firm is lower than that for an organization facing the competitor of a cooperative.

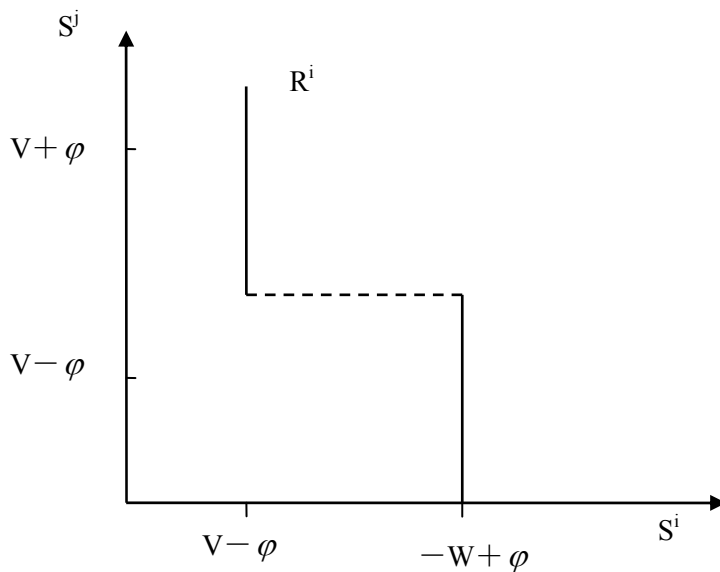


Figure 4 Reaction Function of Organization i , $i=C, F$, $j=C, F$

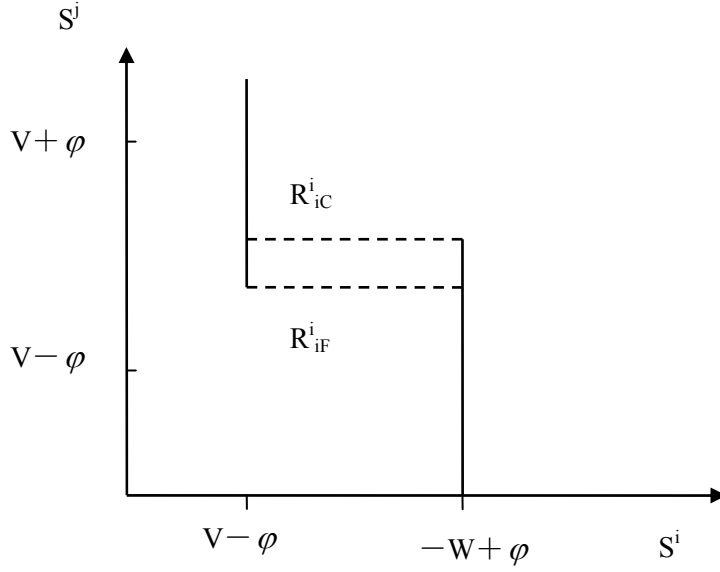


Figure 5 Reaction Functions of Organization i, $i=F,C$, $j=F,C$

As we know, the optimum expected payoff maximizing screening levels are given by the intersection point of two reaction functions at equilibrium. Appendix 3 calculates the equilibrium results. Table 2 summarizes the equilibrium screening levels for two organizations in each case. When the values of the parameters are such that $\alpha\beta V - (1 - \alpha)W < 0$, tight screening is the dominant strategy for both organizations in four cases, thus the unique equilibrium with both choosing tight screening emerges in four cases. When the values of the parameters are such that $\alpha\beta V - (1 - \alpha)W \geq 0$, the equilibrium is not certain in each case; in general, one organization will choose the tight screening while the other choose the loose screening. For the former situation, economic explanation is obvious. When the possible loss from accepting a bad project overweighs the possible sharing benefits from good projects, preventing type 2 errors are far more important for both organizations. Therefore, it is better to set screening level high, regardless of the competitor's choices. For the latter situation, the competitor's choice directly influences the choice of one organization. If the competitor takes so tight screening that it rejects most bad as well as good projects, the expectation of the benefit associated with accepting good projects are increased for the organization, because it is less possible to share the benefit; thus, it is better for the organization to take loose screening to take advantage of less type 1 errors. If the competitor takes so loose screening that it accepts most good as well as bad projects, the expectation of the benefit associated with accepting good projects are sharply reduced for the organization because it has to share the benefit; thus, it is better for the organization to take tight screening to prevent type 2 errors.

	Values of V, W, α, β	
	$\alpha\beta V - (1 - \alpha)W < 0$	$\alpha\beta V - (1 - \alpha)W \geq 0$
FF	$(-W + \varphi, -W + \varphi)$	$(-W + \varphi, V - \varphi)$ or $(V - \varphi, -W + \varphi)$
FC	$(-W + \varphi, -W + \varphi)$	$(-W + \varphi, V - \varphi)$ or $(V - \varphi, -W + \varphi)$
CF	$(-W + \varphi, -W + \varphi)$	$(-W + \varphi, V - \varphi)$ or $(V - \varphi, -W + \varphi)$
CC	$(-W + \varphi, -W + \varphi)$	$(-W + \varphi, V - \varphi)$ or $(V - \varphi, -W + \varphi)$

Table 2 Expected Payoff Maximizing Screening Level

Stage 1: Architecture choice

The payoff-maximizing architecture choice in duopoly is determined by the calculation of the Nash Equilibrium. Table 3 presents the strategic form regarding architecture choice in a duopoly. The payoff associated with each entry are formulated and calculated in the following.

Architecture i	Architecture j	
	Cooperative	Investor-owned Firm
Cooperative	(Y_{CC}, Y_{CC})	(Y_{CF}, Y_{FC})
Investor-owned Firm	(Y_{FC}, Y_{CF})	(Y_{FF}, Y_{FF})

Table 3 Strategic Form of Architecture Choice Game

The duopoly results are presented in Figure 6.³ Two segments of the parameter space are distinguished by the line C, which locates $\alpha\beta V - (1 - \alpha)W = 0$. The duopoly choices in each segment are indicated. For example, (F, C) indicates that the duopoly will consist at equilibrium of one investor owned firm and one cooperative.

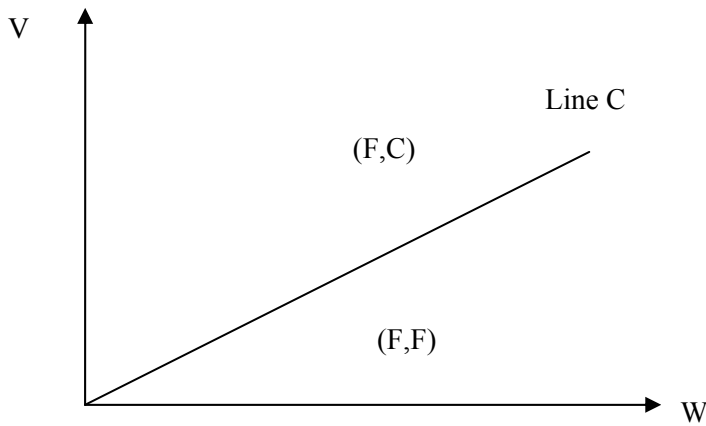


Figure 6 Payoff-Maximizing Architecture Choice in a Duopoly Market

The duopoly choices deserve some comments. Several comparative static results are similar to the monopoly situation. The comparative statics results regarding the size of the two segments are determined by the characteristics of the portfolio of projects. The gains associated with good projects (V), the costs associated with bad projects ($-W$), and the portfolio quality (α) have similar effects. A higher gain (lower costs, improved portfolio) will increase the range of parameter values for which a cooperative is chosen.

Notice β have a negative effect on the choice of cooperative. As β decrease toward zero, the range of parameter values for which a cooperative is chosen will be reduced. This result has important economic implication. It implies that the as the competition increases, the architecture of cooperative become less attractive. This implication is in accordance with the reality. For example, in agriculture markets where cooperatives are active players, drastically increased competition since 1980s has been reported in the literature. At the same time, many cooperatives are also reported to change the traditional structure in many ways, including switching to investor-owned firm structure or adopting more IOF relevant properties.

In accordance with Hendrikse (1998), two different organizational structures may coexist in equilibrium. A cooperative is sustained in such an equilibrium because it faces a higher expected revenue of good projects in either a monopoly or duopoly. This is due to a cooperative is loose in screening level, which entails higher probability of accepting a (good) project. This effect compensates for being cumbersome in screening projects. An investor-owned firm is sustained because it reduces the expected costs associated with bad projects in either a monopoly or duopoly. This is due to an investor-owned firm is tight in screening level, which results in a smaller probability of accepting a (bad) project. This effect compensates for being more often on the wrong track.

³ Appendix 4 provides the calculations.

However, when the screening rule is endogenous, there is no equilibrium where two cooperatives compete.

Parameter values can be determined such that a monopolist chooses a cooperative in the absence of an entry threat, whereas it may switch from the cooperative architecture to the investor-owned firm when facing the threat of new entrants. This strategic choice is captured by the segment between the line A and the line C in Figure 7. According to Figure 3 in the monopoly case, a cooperative is chosen if the values of V and W fall into the area between Line A and Line B. However, the switch from the cooperative architecture to the investor-owned firm architecture seems attractive as long as

$\frac{1-\alpha}{\alpha}W < V < \frac{1-\alpha}{\alpha\beta}W$, because taking investor-owned firm is a dominant strategy for any firms in the market. This observation suggests that the threat of competition from outsiders may induce a cooperative to switch its current architecture to the investor-owned firm architecture to take advantage of decentralized decision making structure.

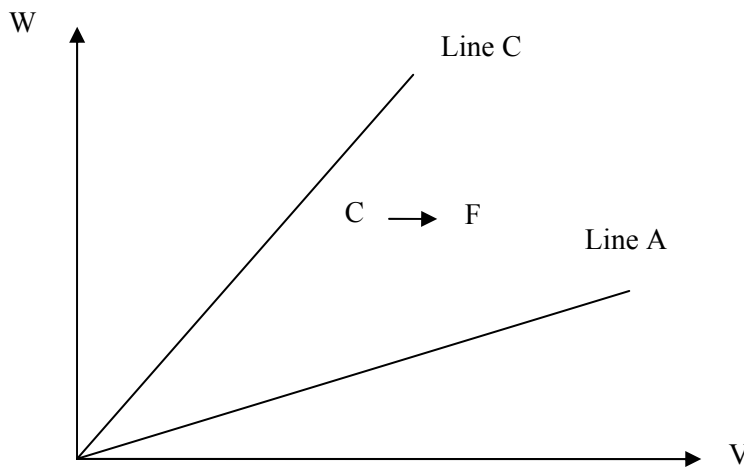


Figure 7 Strategic Space for a Cooperative

4 Summary and Further Researches

Understanding the decision making process in an organization is significant to both organisational economics and industrial organization because it provides insights on optimum governance of firms and efficient industry structure. In this paper we try to explain the differences between cooperatives and investor-owned firms by focusing on the structure of decision making. A model is developed to explore how endogenous screening rules affect efficient organizational choices and industrial structures. It is shown that screening level choice may outweigh architecture choice and that screening rules are strategic substitutes. Conditions are derived under which cooperatives are efficient organizational forms. It is also shown that investor-owned firms become more desirable as competition increase. The circumstances are determined in which cooperatives and investor owned firms coexist in equilibrium.

The introduction of endogenous screening levels shows that previous results are not robust (Hendrikse, 1998). Making screening level choice endogenous seems obvious, because decision makers in organizations use, and therefore choose, criteria to evaluate investment projects. It is also natural to expect that they take into account in their screening level choice that they are decision makers within a certain architecture. However, the empirical evidence seems to be more in line with the exogenous than the endogenous screening level choice model. More research, empirical as well as theoretical, regarding the internal decision making process in cooperatives is required.

One potential research direction is to differentiate the two decision-making units in cooperatives. The farmer as the up-stream decision-making unit may behave differently from the down-stream counterparts. For example, Cook once points out that farmers in cooperatives face portfolio problem. Taking the portfolio problem faced by the farmer into the current model may explain why the impact

of screening level choice is stronger than the impact of architecture choice. Another potential research direction is to refine the current model by substituting the assumption of uniform distribution of noise vector with other distribution assumptions.

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Appendix 1 Screening level choice in monopoly by different architectures

Firstly, Consider a cooperative with bureau i and bureau j. Bureau i maximizes the expected payoff by choosing optimum reservation level S^i . The expected payoff is given as follows:

$$\begin{aligned} & \alpha V \frac{V + \varphi - S^i}{2\varphi} p(V, S^j) - (1 - \alpha)W \frac{-W + \varphi - S^i}{2\varphi} p(-W, S^j) \\ &= \left\{ \frac{(1 - \alpha)W p(-W, S^j)}{2\varphi} - \frac{\alpha V p(V, S^j)}{2\varphi} \right\} S^i \\ & \quad + \frac{\alpha V (V + \varphi) p(V, S^j)}{2\varphi} - \frac{(1 - \alpha)W (-W + \varphi) p(-W, S^j)}{2\varphi} \end{aligned}$$

It is a linear function. When $\frac{(1 - \alpha)W p(-W, S^j)}{2\varphi} - \frac{\alpha V p(V, S^j)}{2\varphi} > 0$, the expected payoff maximizing reservation level is the upper bound, i.e. $-W + \varphi$; when $\frac{(1 - \alpha)W p(-W, S^j)}{2\varphi} - \frac{\alpha V p(V, S^j)}{2\varphi} < 0$, the expected payoff maximizing reservation level is the lower bound, i.e. $V - \varphi$; when $\frac{(1 - \alpha)W p(-W, S^j)}{2\varphi} - \frac{\alpha V p(V, S^j)}{2\varphi} = 0$, bureau i is indifference to $-W + \varphi$ and $V - \varphi$.

Therefore, in a (W, V) space for a given level of α , the line such that $\frac{(1 - \alpha)W p(-W, S^j)}{2\varphi} - \frac{\alpha V p(V, S^j)}{2\varphi} = 0$ captures where $-W + \varphi$ and $V - \varphi$ are indifferent to a cooperative. Line A in Figure 1 depicts it. For Line A, $W=0$ if $V=0$. What's more, we have $\frac{dV}{dW} = \frac{(1 - \alpha)p(-W, S^j)}{\alpha p(V, S^j)}$. Since $p(V, S^j)$ and $p(-W, S^j)$ can not be equal to 1 at the same time, we have $\frac{dV}{dW} = \frac{(1 - \alpha)p(-W, S^j)}{\alpha p(V, S^j)} > 0$.

Secondly, Consider an investor-owned firm with one bureau i. Bureau i maximizes the expected payoff by choosing optimum reservation level S^i . The expected payoff is given as follows:

$$\begin{aligned} & \alpha V \frac{V + \varphi - S^i}{2\varphi} - (1 - \alpha)W \frac{-W + \varphi - S^i}{2\varphi} \\ &= \left\{ \frac{(1 - \alpha)W - \alpha V}{2\varphi} \right\} S^i + \frac{\alpha V (V + \varphi)}{2\varphi} - \frac{(1 - \alpha)W (-W + \varphi)}{2\varphi} \end{aligned}$$

It is a linear function. When $\frac{(1 - \alpha)W - \alpha V}{2\varphi} > 0$, the expected payoff maximizing reservation level is the upper bound, i.e. $-W + \varphi$; when $\frac{(1 - \alpha)W - \alpha V}{2\varphi} < 0$, the expected payoff maximizing reservation level is the lower bound, i.e., $V - \varphi$; when $\frac{(1 - \alpha)W - \alpha V}{2\varphi} = 0$, bureau i is indifferent to $-W + \varphi$ and $V - \varphi$.

Therefore, in a (W, V) space for a given level of α , the line such that $\frac{(1 - \alpha)W - \alpha V}{2\varphi} = 0$ captures where $-W + \varphi$ and $V - \varphi$ are indifferent to an investor-owned firm. Line B in Figure 1 depicts it. For line B, $W=0$ if $V=0$. What's more, we have $\frac{dV}{dW} = \frac{1 - \alpha}{\alpha} > 0$.

It is easy to see that line B is steeper than line A in a (W, V) space for a given level of α , because

$$\left(\frac{dV}{dW}\right)_{LineB} - \left(\frac{dV}{dW}\right)_{LineA} = \frac{1-\alpha}{\alpha} - \frac{(1-\alpha)p(-w, S^j)}{\alpha p(V, S^j)} = \frac{1-\alpha}{\alpha} \times \left[1 - \frac{(-W + \varphi - S^j)/2\varphi}{(V + \varphi - S^j)/2\varphi}\right] > 0.$$

Appendix 2 the Reaction Function in Three Cases

Case 1: two investor-owned firms (FF)

Given the choice for architecture, architecture i maximizes its expected payoff by choosing payoff maximizing reservation levels. That is,

$$MAX_{S^i} Y_{FF}^i = \alpha V p(V, S^i) [1 - (1-\beta)p(V, S^j)] - (1-\alpha)W p(-W, S^i).$$

The first order condition reads $\frac{\partial Y_{FF}^i}{\partial S^i} = \frac{1}{2\varphi} \{ (1-\alpha)W - \alpha V [1 - (1-\beta)p(V, S^j)] \}$.

The optimum screening level is corner solution due to $Y_{FF}^i(S^i)$ is linear. In specific, for the values of V and W satisfying $\alpha V \geq (1-\alpha)W$, we have

$$S^{i*} = R(S^j) = \begin{cases} V - \varphi & \text{if } S^j > V + \varphi - 2\varphi [\alpha V - (1-\alpha)W / \alpha(1-\beta)V] \\ -W + \varphi & \text{if } S^j \leq V + \varphi - 2\varphi [\alpha V - (1-\alpha)W / \alpha(1-\beta)V] \end{cases}$$

We can get the reaction function of architecture j in the same way because of the symmetry of the two firms. In specific, for architecture j, we have

$$S^{j*} = R(S^i) = \begin{cases} V - \varphi & \text{if } S^i > V + \varphi - 2\varphi [\alpha V - (1-\alpha)W / \alpha(1-\beta)V] \\ -W + \varphi & \text{if } S^i \leq V + \varphi - 2\varphi [\alpha V - (1-\alpha)W / \alpha(1-\beta)V] \end{cases}$$

Case 2: Two cooperatives (CC)

Given the choice of architecture, individual organizations (organization i and j) will maximize their expected payoffs (i.e. Y_{ij}) by choosing the payoff maximizing reservation level. That is, architecture i and architecture j will maximize their expected payoffs respectively, taking its competitor's reservation level into consideration. For architecture i, it maximizes the expected payoff Y_{CC} , i.e.,

$$MAX_{S^i} Y_{CC}^i = \alpha V p(V, S^i)^2 [1 - (1-\beta)p(V, S^j)^2] - (1-\alpha)W p(-W, S^i)^2.$$

The first order condition reads

$$\frac{\partial Y_{CC}^i}{\partial S^i} = 2\alpha V p(V, S^i) p'(V, S^i) [1 - (1-\beta)p(V, S^j)^2] - 2(1-\alpha)W p(-W, S^i) p'(-W, S^i).$$

To maximize the expected payoff, the optimum reservation level should satisfy $\partial Y_{CC}^i / \partial S^i = 0$. It gives us the expression for S^i as a function of the other organization's reservation level S^j , i.e.

$$S^{i*} = \varphi + \frac{\alpha V^2 [1 - (1-\beta)p(V, S^j)^2] + (1-\alpha)W^2}{\alpha V [1 - (1-\beta)p(V, S^j)^2] - (1-\alpha)W}.$$

It follows that $\frac{\partial S^{i*}}{\partial S^j} = -\frac{(1-\beta)(1-\alpha)(V+W)\alpha V W p(V, S^j)}{\varphi \{ \alpha V [1 - (1-\beta)p(V, S^j)^2] - (1-\alpha)W \}^2} \leq 0$, because $p(V, S^j) \in [0, 1]$.

The discontinuity point for architecture i is such that $\alpha V [1 - (1-\beta)p(V, S^j)^2] - (1-\alpha)W = 0$, i.e.

$S^{j^*} = V + \varphi - 2\varphi \sqrt{(\alpha V - (1-\alpha)W) / (1-\beta)\alpha V}$. In specific, for the values of V and W satisfying $\alpha V \geq (1-\alpha)W$, we have

$$S^{i*} = R(S^j) = \begin{cases} V - \varphi & \text{if } S^j > V + \varphi - 2\varphi\sqrt{(\alpha V - (1-\alpha)W)/(1-\beta)\alpha V} \\ -W + \varphi & \text{if } S^j \leq V + \varphi - 2\varphi\sqrt{(\alpha V - (1-\alpha)W)/(1-\beta)\alpha V} \end{cases}.$$

We can get the reaction function of organization j in the same way, because of the symmetry of two organizations. In detail, for organization j, we have

$$S^{j*} = R(S^i) = \begin{cases} V - \varphi & \text{if } S^i > V + \varphi - 2\varphi\sqrt{(\alpha V - (1-\alpha)W)/(1-\beta)\alpha V} \\ -W + \varphi & \text{if } S^i \leq V + \varphi - 2\varphi\sqrt{(\alpha V - (1-\alpha)W)/(1-\beta)\alpha V} \end{cases}.$$

Case 3: a cooperative and an investor-owned firm (CF)

For architecture i, it maximizes the expected payoff Y_{CF}^i ; for architecture j, it maximizes the expected payoff Y_{CF}^j . That is,

$$\text{MAX}_{S^i} \quad Y_{CF}^i = \alpha V p(V, S^i)^2 [1 - (1-\beta)p(V, S^j)] - (1-\alpha)W p(-W, S^i)^2,$$

$$\text{MAX}_{S^j} \quad Y_{CF}^j = \alpha V p(V, S^j) [1 - (1-\beta)p(V, S^i)^2] - (1-\alpha)W p(-W, S^j).$$

For organization i, the first order condition reads

$$\frac{\partial Y_{CF}^i}{\partial S^i} = 2\alpha V p(V, S^i) p'(V, S^i) [1 - (1-\beta)p(V, S^j)] - 2(1-\alpha)W p(-W, S^i) p'(-W, S^i).$$

To maximize the expected payoff, the optimum reservation level should satisfy $\partial Y_{CF}^i / \partial S^i = 0$. It gives us the expression for S^i as a function of the other organization's reservation level S^j , that is,

$$S^{i*} = \varphi + \frac{\alpha V^2 [1 - (1-\beta)p(V, S^j)] + (1-\alpha)W^2}{\alpha V [1 - (1-\beta)p(V, S^j)] - (1-\alpha)W}.$$

It follows that $\frac{\partial S_1^*}{\partial S_2} = -\frac{\alpha(1-\alpha)(1-\beta)VW(V+W)}{\varphi\{\alpha V [1 - (1-\beta)p(V, S^j)] - (1-\alpha)W\}^2} \leq 0$. In specific, for the values of V and W satisfying $\alpha V \geq (1-\alpha)W$, we have

$$S^{i*} = R(S^j) = \begin{cases} V - \varphi & \text{if } S^j > V + \varphi - 2\varphi[(\alpha V - (1-\alpha)W)/\alpha(1-\beta)V] \\ -W + \varphi & \text{if } S^j \leq V + \varphi - 2\varphi[(\alpha V - (1-\alpha)W)/\alpha(1-\beta)V] \end{cases}.$$

For organization j, the first order condition reads

$$\frac{\partial Y_{CF}^j}{\partial S^j} = \alpha V p'(V, S^j) [1 - (1-\beta)p(V, S^i)^2] - (1-\alpha)W p'(-W, S^j) = \frac{1}{2\varphi} \{ (1-\alpha)W - \alpha V [1 - (1-\beta)p(V, S^i)^2] \}.$$

The optimum solution is corner solution due to $Y_{CF}^j(S^j)$ is linear. In specific, for the values of V and W satisfying $\alpha V \geq (1-\alpha)W$, we have

$$S^{j*} = R(S^i) = \begin{cases} V - \varphi & \text{if } S^i > V + \varphi - 2\varphi\sqrt{(\alpha V - (1-\alpha)W)/\alpha(1-\beta)V} \\ -W + \varphi & \text{if } S^i \leq V + \varphi - 2\varphi\sqrt{(\alpha V - (1-\alpha)W)/\alpha(1-\beta)V} \end{cases}.$$

Figure 5 in the text summarizes these results in three cases.

The value of the discontinuity point differs depending on the architecture choice of both organizations. Three points are worth pointing out here. Firstly, the values of the discontinuity points fall within the area $[V - \varphi, V + \varphi]$. Secondly, the value of the discontinuity point for a cooperative facing an investor-owned firm equals that for an investor-owned firm facing an investor-owned firm, while that for a cooperative facing a cooperative equals that for an investor-owned firm facing a cooperative. Thirdly, the discontinuity point for an organization (either a cooperative or an investor-owned firm) facing the competitor cooperative is larger than that for an organization facing the competitor investor-owned firm. It is captured in Figure 6.

Appendix 3 Expected Payoff Maximizing Screening Levels at equilibrium

In this appendix, we illustrate how optimal screening levels are determined at equilibrium. The method is to draw reaction functions for two organizations and then locate the intersected point in each possible case.

We distinguish two cases regarding the values of the parameter variables such as V, W, φ, β .

Case 1: $\alpha\beta V - (1 - \alpha)W < 0$

All discontinuity points are higher than $-W + \varphi$ and lower than $V + \varphi$ in this case. The following three figures illustrate how optimum screening levels are determined by the intersection of the reaction functions in three market situations (i.e., FF, CC, CF).

Figure Appendix 3-case 1A depicts the reaction functions of two investor-owned firms, where the discontinuity points for either firms are both $V + \varphi - 2\varphi[\alpha V - (1 - \alpha)W / \alpha(1 - \beta)V]$. It shows that the equilibrium consists of $(-W + \varphi, -W + \varphi)$.

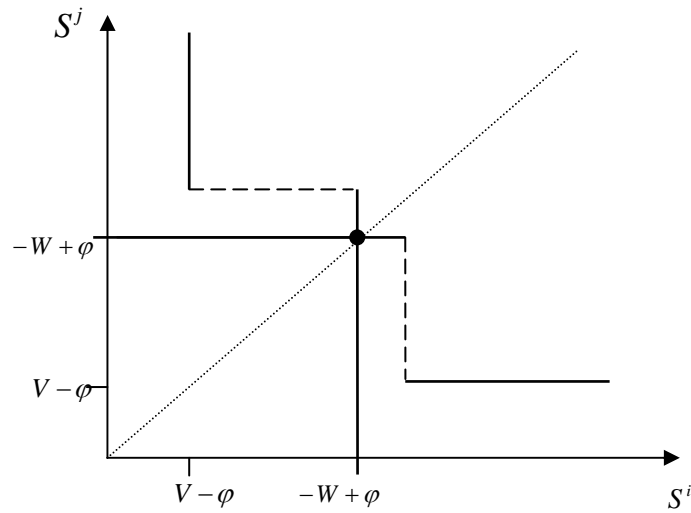


Figure Appendix 3-case 1A: Expected payoff maximizing screening level of two IOFs

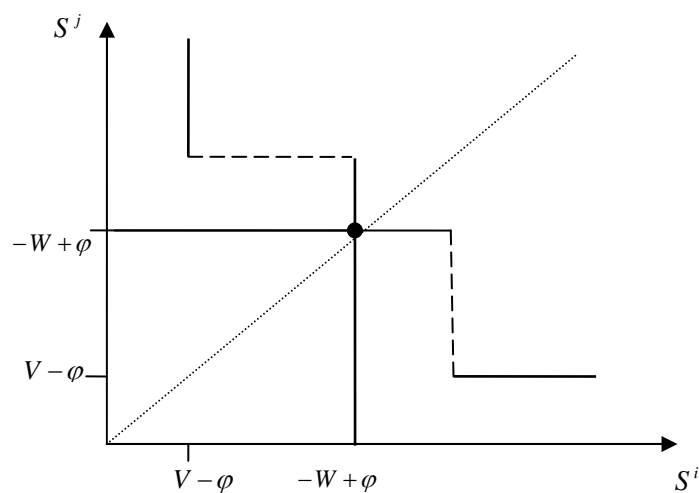


Figure Appendix 3-case 1B Expected payoff maximizing screening levels of two cooperatives

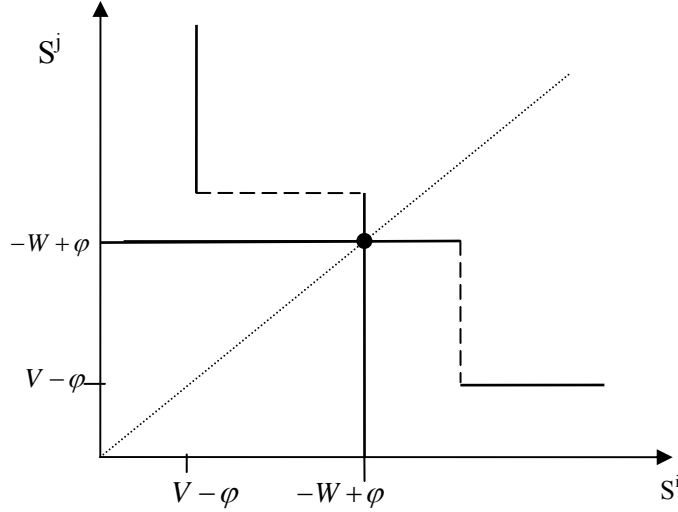


Figure Appendix 3-case 1C Expected payoff maximizing screening levels of a cooperative and IOF

Figure Appendix 3-case 1B depicts the reaction functions of two cooperatives, where the discontinuity points for either firm are both $V + \varphi - 2\varphi\sqrt{(\alpha V - (1 - \alpha)W)/(1 - \beta)\alpha V}$. It shows that the equilibrium consists of $(-W + \varphi, -W + \varphi)$.

Figure Appendix 3-case 1C depicts the reaction functions of a cooperative and an IOF. For the cooperative, the discontinuity point is $V + \varphi - 2\varphi[\alpha V - (1 - \alpha)W / \alpha(1 - \beta)V]$, while it is $V + \varphi - 2\varphi\sqrt{(\alpha V - (1 - \alpha)W)/(1 - \beta)\alpha V}$ for the IOF. For convenient, suppose $i=\text{cooperative}$ and $j=\text{IOF}$. It shows that the equilibrium consists of $(-W + \varphi, -W + \varphi)$.

In sum, the above figures show that the equilibrium screening levels for the two organizations are all $-W + \varphi$.

Case 2: $\alpha\beta V - (1 - \alpha)W \geq 0$

In this case, the values of the discontinuity points all fall into the area $[V - \varphi, -W + \varphi]$. The following three figures illustrate how optimum screening levels are determined by the intersection of the reaction functions in three market situations (i.e., FF, CC, CF).

Figure Appendix 3-case 2A depicts the reaction functions of two investor-owned firms, where the discontinuity points for either firms are both $V + \varphi - 2\varphi[\alpha V - (1 - \alpha)W / \alpha(1 - \beta)V]$. It shows that the equilibrium consists of $(V - \varphi, -W + \varphi)$.

Figure Appendix 3-case 2B depicts the reaction functions of two cooperatives, where the discontinuity points for either firm are both $V + \varphi - 2\varphi\sqrt{(\alpha V - (1 - \alpha)W)/(1 - \beta)\alpha V}$. It shows that the equilibrium consists of $(V - \varphi, -W + \varphi)$.

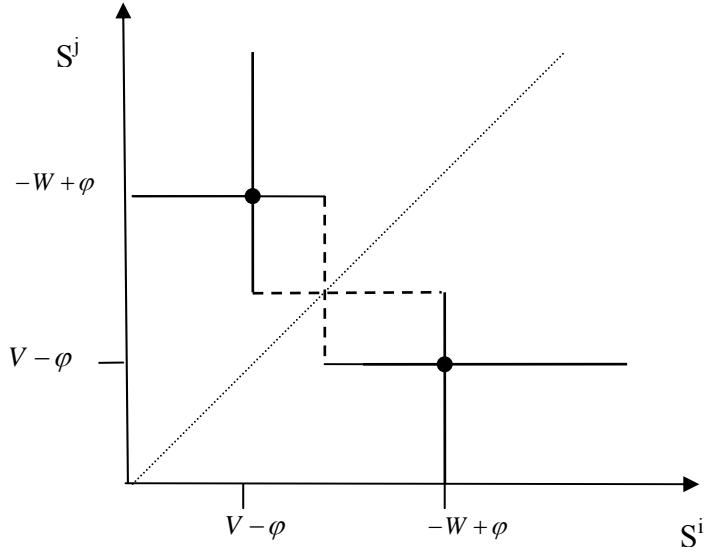


Figure Appendix 3-case 2A Expected payoff maximizing screening level of two IOFs

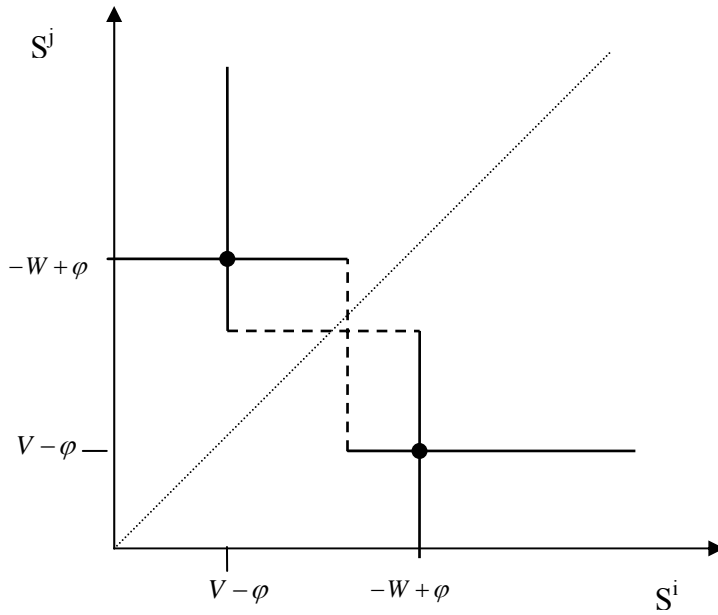


Figure Appendix 3-case 2B Expected payoff maximizing screening level of two cooperatives

Figure Appendix 3-case 2C depicts the reaction functions of a cooperative and an IOF. For the cooperative, the discontinuity point is $V + \varphi - 2\varphi[\alpha V - (1 - \alpha)W / \alpha(1 - \beta)V]$, while it is $V + \varphi - 2\varphi\sqrt{(\alpha V - (1 - \alpha)W) / (1 - \beta)\alpha V}$ for the IOF. For convenient, suppose $i=\text{cooperative}$ and $j=\text{IOF}$. It shows that the equilibrium consists of $(V - \varphi, -W + \varphi)$.

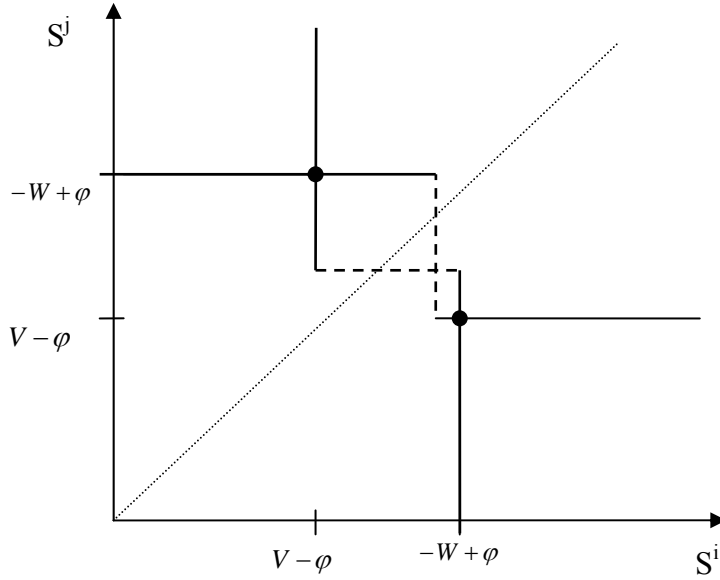


Figure Appendix 3-case 2C Expected payoff maximizing screening level of a cooperative and IOF

Appendix 4 Architecture Choice in Duopoly Market

We distinguish two cases regarding the values of the parameter variables. The architecture choice at equilibrium will be calculated in the following.

Case 1: $\alpha\beta V - (1 - \alpha)W < 0$

In this area, the screening levels at equilibrium are $(-W + \varphi, -W + \varphi)$. Note the expected payoff for one firm as Y_{ij} , where ij means firm i (either F or C) facing the competition of firm j (either F or C). Tight screening here means that both firms reject all bad projects. Thus, we have

$$\begin{aligned}
 Y_{FF} &= \alpha V p(V, -W + \varphi) [1 - (1 - \beta) p(V, -W + \varphi)] - (1 - \alpha) W p(-W, -W + \varphi) \\
 &= \alpha V p(V, -W + \varphi) [1 - (1 - \beta) p(V, -W + \varphi)] \\
 Y_{CC} &= \alpha V p(V, -W + \varphi)^2 [1 - (1 - \beta) p(V, -W + \varphi)^2] - (1 - \alpha) W p(-W, -W + \varphi)^2 \\
 &= \alpha V p(V, -W + \varphi)^2 [1 - (1 - \beta) p(V, -W + \varphi)^2] \\
 Y_{FC} &= \alpha V p(V, -W + \varphi) [1 - (1 - \beta) p(V, -W + \varphi)^2] - (1 - \alpha) W p(-W, -W + \varphi) \\
 &= \alpha V p(V, -W + \varphi) [1 - (1 - \beta) p(V, -W + \varphi)^2] \\
 Y_{CF} &= \alpha V p(V, -W + \varphi)^2 [1 - (1 - \beta) p(V, -W + \varphi)] - (1 - \alpha) W p(-W, -W + \varphi)^2 \\
 &= \alpha V p(V, -W + \varphi)^2 [1 - (1 - \beta) p(V, -W + \varphi)]
 \end{aligned}$$

Given its rival choosing the architecture of cooperative, the expected payoff maximizing architecture for the organization is investor owned firm, because $Y_{CC} - Y_{FC} < 0$. Given its rival choosing the architecture of investor owned firm, the expected payoff maximizing architecture for the organization is also investor owned firm, because $Y_{CF} - Y_{FF} < 0$. In sum, if organizations are rational and try to maximize their expected payoffs, choosing investor owned firm is one dominant strategy.

Therefore, (F,F) constitutes Nash equilibrium. The economics behind this is that there are no type II errors when the screening levels are $-W+\phi$. It is important to prevent type I errors in this case. Since the investor-owned firm is good at preventing type I errors, it immediately follows that two organizations will both choose the architecture of investor-owned firm to increase their expected payoffs. No organization has motives to deviate from such an outcome, which constitutes exactly what is defined as Nash equilibrium.

It is worth pointing out that the market structure of (F,F) is also an efficient structure in this case. In case that the equilibrium screening levels are tight enough to get rid of all possible bad projects, accepting more good projects will bring more profits from the perspective of whole society. Since investor owned firms are good at preventing type I errors, the market structure consisting of two investor-owned firms are more efficient than any other industrial structures.

Case 2: $\alpha\beta V - (1 - \alpha)W \geq 0$

In this case, equilibrium screening levels are $(V - \phi, -W + \phi)$ or $(-W + \phi, V - \phi)$ for firm i and j. Without loss of generality, we suppose firm i chooses $-W + \phi$ and firm j chooses $V - \phi$ at equilibrium. It implies that firm i rejects all bad projects while firm j accepts all good projects. For firm i, this situation is very similar to the monopoly situation, except that V has to be replaced by βV . Because there are no type II errors, preventing type I errors are significant. Consequentially, the architecture of investor-owned firm is preferred because it is good at preventing type I errors. On the contrary, there are no type I errors for firm 2. Because there are no type I errors, it is important to prevent type II errors and thus the architecture of cooperative firm is preferred. Therefore, (F, C) constitutes the equilibrium architecture choice.

Further, No firms are motivated to deviate from this equilibrium result. Given that firm 2 chooses cooperative, deviation from investor-owned firm to cooperative will reduce firm 1's expected payoffs, because $Y_{CC} - Y_{FC} = \alpha\beta V p(V, -W + \phi)^2 - \alpha\beta V p(V, -W + \phi) < 0$. Given that firm 1 chooses investor-owned firm, deviation from cooperative to investor-owned firm will also reduce firm 2's expected payoff, because

$$Y_{FF} - Y_{CF} = \{\alpha V [1 - (1 - \beta)p(V, -W + \phi)] - (1 - \alpha)W p(-W, V - \phi)\} \\ - \{\alpha V [1 - (1 - \beta)p(V, -W + \phi)] - (1 - \alpha)W p(-W, V - \phi)^2\} < 0$$