“Controlled Competition”: Dynamic Tournaments as Economic Development Strategy: A Viewpoint from Incentive Design

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Abstract

This paper builds a model of dynamic tournaments under incomplete contract situations to analyze how the government, as a national development strategy, induces incentives or forms of competition between multiple companies (between state-owned enterprises (SOEs), between private-owned enterprises(POEs), or between SOEs and POEs) in the long-run. This paper can be considered as a model analysis of “controlled competition” under “State Capitalism”, in which the government participates in the market as an active player, such as in China, Singapore, and in a broad sense, in Japanese Industrial Policy in the past. In addition to clarifying the incentive mechanism embedded in this model, we also examine the problems and areas for improvement from the perspective of incentive design. In particular, in the long-term competition between two heterogeneous companies, it would be a beneficial policy for the government if the feedback effect could be mitigated by handicapping the winner and favoring the loser, thereby restoring the competitive pressure that had decreased. At the same time, as excessive competition-inhibiting discriminatory prizes (“Cronyism”) greatly impede investment incentives for both companies, these can be viewed as a "government failure", and thus the institution should be redesigned to correct such obstacles, thereby maintaining appropriate competitive pressures.

Key Words: Controlled Competition, State Capitalism, Dynamic Tournaments, Incomplete Contracts, Heterogeneity, Cronyism.
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1. Introduction

The purpose of this paper is to use **a model of dynamic tournaments under situations of incomplete contracts**, as a national growth strategy, in order to examine how governments can induce a long-term form of competition between multiple agents (state-owned enterprises (SOEs), private-owned enterprises(POEs), or SOEs and POEs). The paper can be viewed as **a model analysis of "Controlled Competition" under "State Capitalism"**, in which the government participates in the market as an active player, such as in China, Vietnam, Singapore and in a broad sense, the Japanese Industrial Policy in the past, among the diversity of capitalism including Asian capitalism. In this paper, an intertemporal incentive mechanism incorporated into "Controlled Competition" as well as its defects, problems, and improvability will be closely investigated.

The role of national leaders is crucial in economic development. This is because economic development is closely related to the policies and reforms implemented by state leaders. (Aghion et al. (2004)'s "Endogenous Political Institution" takes a holistic view of constitutional design for optimizing reform incentives by national leaders.)

Recently in Asia, the influence of China, which has emerged and increased its presence through the reform and opening-up along with marketization introduced since 1978, has become extremely large. This is not only because China is an international political power, but also because it has surpassed Japan in GDP since 2010 and emerged as the world's second largest economy, **building its own national capitalist system (the "Chinese model" or "Chinese capitalism")), a socialist market economy**. The Communist Party of China (CCP) has transformed its administration into an organization with a supreme priority of staying in power rather than the realization of the ideology of communism, and has been emphasizing economic growth. The form of development of China, which promoted the market economy led by the government in a form that lacks political democracy is called the **"Beijing Consensus"**, and this is attracting attention as a crucial factor in its economic development.

In particular, the Beijing Consensus can be interpreted as an agreement on the policies of developing countries formed under China's leadership after the Lehman shock (2008), and one key word is **"control"**. In the struggle for supremacy between **Free Capitalism** [1] and **State Capitalism**, the Chinese government has introduced the economic system termed **"State Capitalism"**, which implements **economic management that gradually promotes liberalization while retaining strong control**. After the Lehman shock in 2008, while the free capitalism of Western countries experienced negative growth across the board, the fact that China has supported and driven the growth of the global economy has led the world to pay attention to the economic development model of China with "control" as one of its keywords. International political scientist Ian Bremmer (2010) pointed to China as a central state promoting "State Capitalism." Liebman and Milhaupt (2016) gives an explanation that "Chinese state capitalism" connotes an economic approach involving (1) a comparatively high degree of direct state participation in the economy, and (2) the use of capitalist forms of economic organization—markets, enterprises, and other investment vehicles—in combination with nondemocratic forms of public governance.[2]

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[1] Also known as the **"Washington Consensus,"** it consists of neoliberal policy packages that include deregulation, reduction of fiscal deficits, liberalization of capital markets, and privatization of state-owned enterprises.

[2] Although China is by no means the world's sole practitioner of state capitalism, it is arguably the most successful, and certainly the largest. China's success might also be a model for other developing countries. (e.g., Vietnam, modeled after

In recent years, the Chinese government has shifted **from the traditional growth model** that emphasizes the input of production factors that led to the "world's factories" **to a new growth model focusing on innovation**, aggressively investing R&D personnel and R&D funds to vigorously promote innovation, quality improvements, and strengthening of its brand power.

However, it goes without saying that despite "state capitalist management," in which the Chinese government provides policy support for companies through subsidies and other means, success or failure will depend on the abilities and incentives of actual company managers.[3] Thus, the form of transactions between government and enterprises and the form of competition between companies will also become important.

When the context is expanded a little more and is positioned within research into **the diversity of capitalism**, it is pointed out that the analysis at the corporate level and the heterogeneity of the enterprises have not thus far been examined to a very great degree. The analysis of enterprises and systems incorporating the heterogeneity of enterprises has become a problem left for the diversity theory of capitalism. **The analysis of dynamic tournaments between heterogeneous agents in this paper could be a response to this request**.

Moreover, research into the diversity of capitalism has often been limited to advanced countries. In other words, the diversity analysis of capitalism including transitional and emerging economies has been sparse. In recent years, the diversity theory of capitalism has expanded into such areas. More importantly, it is pointed out that several emerging economies have appeared, and the global composition of modern capitalism has changed greatly. Especially, since the 1990s, the Asian economies, notably the Chinese economy, have drifted toward the center of the global economy, and the interest of comparative capitalism has also shifted toward **the institutional diversity of Asian capitalism**.

While the research into the diversity of capitalism has produced substantial amounts of empirical results for developed countries (such as Japan-U.S. comparisons, Japan-Germany comparisons, comparisons of corporate governance between the United States, the United Kingdom, Germany, France, and Japan), it is also clear that there are limitations on this research when Asian economies are included in the discussion. Most existing studies regard Asian economies as homogeneous, and Asian capitalism has rarely been taken up as the subject in any research. However, as the center of the global economy rapidly shifted toward the Asian economy, attention to the region increased, and the attempt to position **Asian capitalism** at the top of diversity research on capitalism came to the fore. Empirical studies have found that Asian capitalism is clearly distinguished from the advanced economies institutionally, and that **each economy is institutionally diverse** even within Asian capitalism.

In emerging and transitional economies, states do not only control or coordinate the private economy using regulations and subsidies or financial means. The characteristic of these economies is that the state itself acts as a distinctive player. By including emerging and transitional economies, **states, as such institutions**, have emerged as **a central analytical issue for diversity analysis**. For example, by applying comparative institutional analysis to the Chinese economy, the hierarchical control of the State Asset Supervision and Control Committee over state-owned

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China.)

[3] Milhaupt and Zheng (2015) point out that even state-owned enterprises are controlled by the managers, not by the State. Hart, Shleifer, and Vishny (1997) builds a model such that the manager provides effort for innovation under both public and private ownership structures. Riordan (1991) suggests a model based on ownership without control, where the state has an ownership of the enterprises, but does not have control rights over the decisions.

enterprises (SOEs), the strengthening of government control over strategic industries, and the formation of interest groups that encompass government and SOEs will be clarified. This will present a concrete image of a nation both as a coordinator and an active player in economic development.

Aoki, Kim, and Okuno-Fujiwara (1996) used a "comparative institutional analysis" approach, to analyze "economic development and the role of government in East Asia." **Aoki et al. (1996) positioned the government from a Market-enhance view, reflecting the decentralization era in China** (from the reform and opening-up in 1978 to the tax reform in 1994)[4] . Since 1994, and especially since entering the 21st century, the cycle of government roles has changed to **the "Centralization Era"**, that is, the government's weight in promoting and coordinating the market economy has increased,[5] and since the Lehman shock, it has become the representative of "State Capitalism" (promotion of capitalism by the state) (Ian Bremer et al.), and so the interpretation of the role of the government in economic development will need to be reexamined in accordance with the times.[6]

In Japan, one of the first Asian countries to return to the developed world, **Japanese-style competition** has also played an active role in achieving rapid postwar growth, which has been analyzed for various industries.

Ito (1988) analyzed the form of competition under high economic growth, terming it "growth competition in a greenhouse." He considered the automobile industry from the mid-1950s to the early 1970s as oligopolistic competition (in greenhouses) under industrial policy. In an oligopolistic industry with rapid growth, the competition is more likely to be aimed at maximizing the growth rate or expanding market share than at maximizing short-term profit, due to the large first-mover advantage in terms of investment. In the case of the Japanese automobile industry at the time, the greenhouse state was created to avoid direct competition with foreign enterprises through mechanisms such as import volume restrictions, tariff policies, and inward direct investment regulation, but this was only for a limited period. The analysis therefore shows that there was an earnest purpose regarding how to close the gap with foreign enterprises by the deadline, and that this induced fierce investment competition, collusion between firms not occurring. The analysis found that the government created the "greenhouse, that is, organization" through policy, and indirectly induced the investment incentives of the oligopolistic firms through the temporary protection policy. In addition, the mode of competition in the organization is termed "face-to-face competition," and interesting ideas are presented with examples of competition under the subcontract system.

A second example of the success of the "Japanese" competition system is one under the **"industrial policy"** of

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[4] Qian and Weingast's paper, one of the included papers, is one of the leading studies explaining the rapid economic growth of China in the "Decentralization Era." Qian and Weingast (1996, 1997) point out that a form of decentralization called "Market-Preserving Federalism, Chinese Style" created competition among local governments, which allowed a credible commitment to hard budget constraints on township and village enterprises. They explain that the interest of local governments was allied with the development of the local economy, and protected the property rights of township and village enterprises, giving incentives to them.

[5] Suzuki (2019) used a contract theory framework to analyze the change from the decentralization era (fiscal contracting) to the centralization era (tax sharing) in the context of fiscal relations between central and local governments.

[6] Liebman and Milhaupt (2016) explores the institutional implications of China's transformative development under state capitalism in a comprehensive, in-depth way. Our theoretical analysis will complement their empirical studies.

postwar Japan, including the experience of the Japanese computer industry. In the Japanese economy, there existed distortion and management (Trade Control), which had a sufficiently satisfactory performance. While the control and intervention involved implicit and explicit costs, they involved relatively little resource wastage. The Japanese government selectively promoted capital- and knowledge-intensive industries, regarding which it was agreed that they would enable the fostering of industries (enterprises) with international competitiveness. Such industrial policies used export performance as a yardstick for the policy. The market also accepted the policy due to the results that the policy accelerated the growth of the domestic market, lifted productivity, and improved the quality control system, thereby bringing about economic growth. These are the benefits of government policies, but if policy is considered as a strategy for economic development, the cost of the policy must also be considered. In other words, it is important, from the standpoint of economics focusing on cost-benefit analysis, to analyze not only for the growth (capital accumulation) that has been generated but also the magnitude of the cost required for that purpose. While there has been little theoretical research, this could be analyzed by applying the theory of incentive contract.

The third example of Japanese-style competition is the competition between parts suppliers in the transaction between the assembly manufacturers and parts suppliers. In the automobile and parts industry in Japan, it is known that parts manufacturers (especially the primary manufacturers) have a constant product technology, and are often involved not only in the manufacturing of parts but also in development activity. This system is called “drawings approved” or “design-in,” and is known to bring competitive advantages such as cost reduction in parts manufacturing and component design improvement. Itami (1988) and others have shown that buyers take the form of "controlled" competition in which buyers allow multiple potential suppliers to compete for the position of part supplier, thus maintaining the quality of competition. This form of competition has been introduced in the automotive and parts industries in Europe and the United States since the mid-1990s.

The above is **a summary of three cases** that have been described as typical "Japanese-style" competition schemes. In each case, **the role of the "visible hand"** of the government or the buyer is important in leading the competition.

Based on the above motivation (**attention to "Chinese state capitalism"** in the diversity of Asian capitalism, **promotion of capitalism by the government (state)**, and **reference to the case of "controlled competition" in Japan**, which is another advanced Asian country), the following four points are common features of "controlled competition."

(1) The presence of multiple, but a small number of, fixed agents and a third party (a Visible Hand, such as the government or a buyer) who ranks them.

(2) Under uncertainty situations with high transaction costs where **complete and state-dependent contracts cannot be written**, organizations (in a broad sense) have been formed to conduct ranked competition in the long term .[7]

(3) This is a "competition without losers,” meaning that even if a player loses once in the competition, he or she is not eliminated from the competition, and unlike competition that is harsh for the loser in the selectively eliminating type, the loser has an incentive to try again.

[7] Political stability is essential for economic development. Both the long-term Liberal Democratic Party (LDP) 's government in Japan and The Communist government in China are similar in terms of (domestic) political stability. Even if uncertainty exists, the distribution is predictable and capped.

(4) In the midst of the competition, "dialogues" are held, technical information is exchanged, spillover of knowledge and technology takes place during each period, and there are devices to maintain the quality of a small number of members.

To model these four points in a simple form without losing the essence, it is necessary to introduce a multi-agent model under an incomplete contract situation in which the third party (government, the visible hand) guides the competition or the race in a way that does not exclude the loser. Traditional theoretical research has only incorporated the theory of elimination tournaments (exclusion-type tournaments) and incomplete contracts. Not only are there few models that formally introduce viewpoints (1) and (2), but there are almost no models that explicitly analyze viewpoint (3). One exception is a model describing an "**endogenized tournament**" by Konishi, Okuno-Fujiwara and Suzuki (1994, 1996). This model explicitly introduces the viewpoints (1) through (3) of the "Japanese-style" form of competition, showing that even in a situation of competition without losers under incomplete contract situations, a third party can intervene in the competition and induce firms to run ahead to expand investment in advance if the environment allows it.[8] The paper rigorously analyzes the incentives for losers in the previous competition period to invest in order to reverse the ranks in the next competition period. However, the paper considers only the situation in which the agent voluntarily engages in the ex-post investment competition, and does not fully analyze the implications for the entire ex-ante and ex-post competition (race) of "third party inducing" of the winner and the loser of the ex-ante competition to actively invest ex-post as well. In other words, the strong point of the analysis of KOS (1994) is that under the under-investment situation in relation-specific skill in the incomplete contract environment, tournaments are endogenously created, whereas in this paper, the focus is on the guidance of the races by a "visible hand" (third party (government)), that is, whether the principal adjusts the structure of the organization and efficiently manages the dynamic incentives of the agent in the competition.

In this paper, based on these points, we theoretically analyze how the diachronic competitive form changes depending on the contract offered by the government. Since the framework of the analysis is based on (1) and (2), and places particular emphasis on point (3), "controlled" competition contains the possibility of a "league game" where the loser in the previous period works hard to reverse the situation ex-post. We then analyze the incentive effect of this form of competition from a diachronic viewpoint. In this model, viewpoint (4) is also introduced. This is because, in the case of managed competition, a mechanism in which competitive companies transfer technology to each other is prepared at the end of each period, and corporate behavior in which companies strives to raise their own accumulation ex-post using the assets accumulated by other companies, thereby raising their rank (share) in the industry, is often observed. This point will be introduced into the model in the simplest possible form. Theoretically, it is identical to designing a two-stage procurement competition by a third party (government, sponsor) and characterizing it by the second-best solution, but, unlike usual theories, it is shown that by using not only monetary transfers but also non-monetary incentive schemes (allotment schemes) incentives can be induced at a lower cost.

Related literature may be classified as follows. Since **dynamic tournaments under incomplete contract situations** is the basic framework of our model, Economics of Transaction Costs by Coase (1937), and Williamson

[8] Konishi, et al. (1996) has derived the optimal number of competitors $n^* = 2$.

(1975, 1979), the theoretical literature such as Tirole (1986), Grossman and Hart (1986), and Riordan (1991), which analyzed hold-up problems and their solutions. Further, in addition to the traditional theory of tournaments à la Lazear and Rosen (1981) and Nalebuff and Stiglitz (1983), in particular, **heterogeneous tournaments** (e.g., Gürtler and Kräkel(2010)) are closely related. R&D Innovation contests and races are also related (e.g., Sela (2017)). However, most of these discuss incomplete contracts and/or homogeneous (in some cases, heterogeneous) tournaments, and do not analyze **two-stage tournaments between heterogeneous players with different bargaining powers (ownership ratios) in connection with China's ownership system**. The role of government in economic development (market-enhancing view by Aoki, Kim, Okuno-Fujiwara(1996)) deals with the Chinese government in the decentralization era since reform and opening-up, while on the other hand, reflecting **the recent view of "State Capitalism" in the Centralization Era**, the role of government will be changing to a form where it leads the introduction of capitalism. The model in our paper, based on the latter perspective, in a situation where ownership reform has not been completed, makes clear the necessities and implications of creating a fair competitive environment[9] through the contract theory and industrial organization theory analysis.[10]

This paper presents a model of "controlled competition" under "state capitalism," in which the government participates in the market as an active player, and identifies its perceived flaws in economic theory. In other words, our model analyzes how the government will dynamically induce the form of competition or race between multiple agents (SOEs, POEs, or SOEs and POEs) in the long run, as a national economic development strategy incorporated into "controlled competition" under "state capitalism." The purpose of this paper is to clarify the diachronic incentive mechanisms and their problems from the viewpoint of the theory of incentive design, and to derive implications for institutional reform.

2. Set-up of the Model

With the government procurement setting in mind, we consider two sets of risk-neutral players. The three patterns are the government and two firms (two state-owned enterprises (SOEs), two private-owned enterprises (POEs), and one SOE and one POE). (Henceforth, in abstraction, we refer to these as the principal and two agents.) The firms contract research and development (R&D) activities on behalf of the government, and provide research results to the government. The government exercises discretion over the structure of the form of competition, and firms can invest in R&D innovation. The government (principal) has a choice of several organizational forms, but for the time being we assume that two agents are hired throughout the time.

As can be seen from Fig. 1, there are two periods before production and sales occur. The accumulated capital remains unknown until the end of each period. The capital stock of the agent i at the end of the second period is represented

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9 Kwan (2019) warns against the progress of the SOEs and the regress of the POEs under a mixed ownership system and reiterates the need to build a level playing field. Kwan (2017) summarizes the controversy on “industrial policy” in China.

10 Suzuki (2020) presented a theoretical institutional analysis on the Chinese economy (important topics: fiscal relations between the central and local governments, ownership reform, privatization etc.) using a contract theory and game theory approach. This paper focuses on the controlled competition under state capitalism, which is not included in Suzuki (2020).

by the stochastic variable in equation (1) below.

$$\widetilde{K}_{2i} = K_{i2} + e_i + \varepsilon_i \qquad i = 1,\ 2. \tag{1}$$

Here, K_{i2} is the capital stock of the agent i after the completion of the transfer of technical knowledge or spillover from the end of the first period to the beginning of the second period. As can be seen from this equation, the capital K_{i2} at the beginning of the second period and the investment (effort) level of the agent $e_i \geq 0$ are combined, and then the actual capital stock $\widetilde{K}_{2i}$ is generated by a certain noise ε_i, where ε_i has a mean of 0, and the variance is σ^2. ε_i is independent of any other variable, including ε_j, and the buyer (the government) knows only the distribution of ε. The purpose of both sides, that is, each company and buyer (government), is to maximize each expected private profit (payoff).

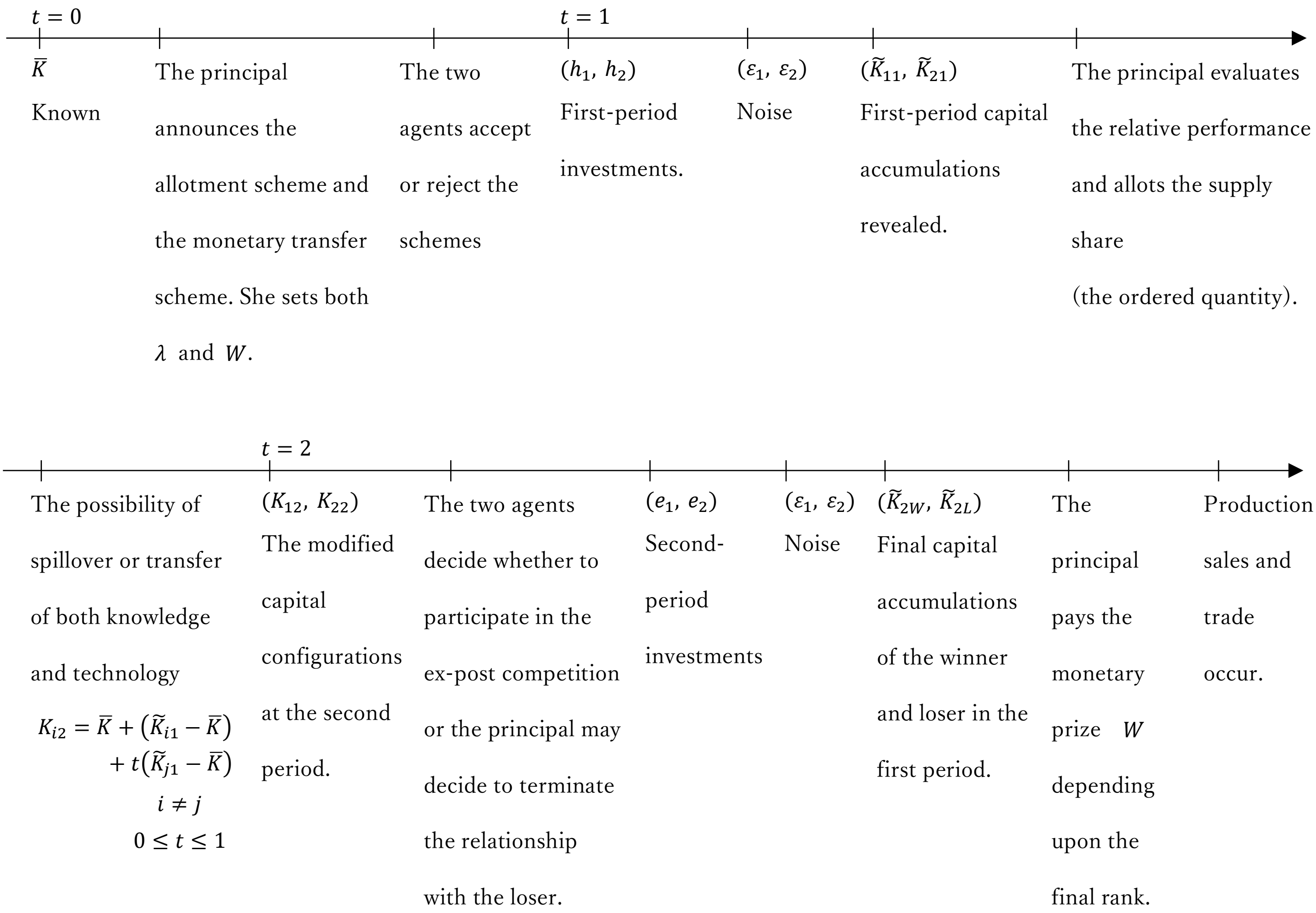

Figure 1

The flow of time and the sequence of events occur as follows: First, the government (principal) offers contracts (policies) to both firms (agents). The contents are the division of the production between agents at the production stage, that is, the production allotment (the order quantity allocation) and the monetary payment. In our model, the former follows the ranking [11] of the two agents based on the results of the capital accumulation competition in the first stage, and the latter follows the result of the competition at the end of the second stage, that is, the ranking based on the final result of the competition. Agents are **symmetrical or asymmetrical from the ex-ante stage**, and make capital accumulation investments independently and simultaneously, given the organizational structure and production allocation scheme announced by the principal and the second period monetary payment as a bonus. The intermediate rank is determined based on the first relative magnitude of the two capital accumulations, and the final rank is determined based on the relative magnitude of the final capital accumulations represented by equation (1). In short, the principal (**Visible Hand**) 's strategy is production (order) allotment and monetary payment, and she can choose the period in which this is to be implemented based on the results of any period.

The agent makes investment decisions to accumulate capital. These investment levels are unverifiable in court and therefore noncontractible variables. The idea of investing over two periods reflects the need to constantly invest to improve the quality of goods. In other words, it can be thought of as a model of a situation in which assets such as technological know-how and production skills are constantly created, improved, and improved again, and fits the Catch-up situation in which the technological level needs to be raised quickly. It can also be thought of as a situation in which R&D innovation takes place over time. [12]

In the final period, if both sides trade, the traded goods will generate a per-unit production value for the government in equation (1). For simplicity, unit production (and sales) costs are assumed to be 0. The surplus of the transaction is thus the final accumulated quality level in equation (1), and the surplus will disappear if the transaction fails. Negotiations on the surplus determine the share of both sides.

2. 1 First-best contract (Overall Optimization) under a Complete Contract Setting

Before discussing the solution of this model in detail, let us characterize what is possible in cases where both principal and agent can write and commit to the complete contract. This will also serve as a benchmark in future analysis. In this case, both parties anticipate creating the capital stock $\widetilde{K}_2$ at the end of the second period represented by formula (1) (which is the gross trading profit at the same time), and determine the levels of investment in the first and second periods such that the expected total surplus of (2) below is maximized. In this case, the externality effect of thinking only about the amount α of the bargaining power of the capital stock $\widetilde{K}_2$ as a private revenue and not considering the positive externality to the principal is excluded.

The objective function at the beginning of the first period in this complete contract regime is

$$\delta \cdot \underset{\varepsilon}{E}\left[Q \cdot \widetilde{K}_2 - C(e)\right] - g(h). \tag{2}$$

and the investment levels $h \geq 0, e \geq 0$ in the first and second period are selected to maximize equation (2).

$g(h)$ and $C(e)$ are the cost functions of the investment, satisfying $C' > 0,\ C'' > 0,\ C''' \geq 0,\ g' > 0,\ g'' \geq 0$.

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[11] W could include not only financial subsidies, but also the expectations for the size of future value through promotions, etc. associated with winning the competition, which is to be interpreted as so-called “continuation value”.

[12] Tirole (1986) refers to military procurement as a good example of incomplete contracts and renegotiation, where any design change is not be specified in the initial contracts for risky research and development (R&D) projects. R&D innovation and design changes would continue until the final stage.

The optimal investment levels h^{FB} and e^{FB} satisfy the following first order conditions (FOCs).

$$Q = C'(e^{FB}). \tag{3}$$

$$\delta Q = g'(h^{FB}). \tag{4}$$

In this case, the hold-up problem of *underinvesting* from the overall point of view no longer occurs, which is generated from the fact that only a certain percentage $\alpha \in [0,1]$ of the value added can be secured. In the complete contract setting, the positive externality exerted on the principal is *internalized*, and the overall optimum (first-best) investment levels h^{FB} and $e^{FB}$are spent.

2. 2 Hold-up problems under an Incomplete Contract Setting (Strategic Agents make Private Optimalization)

However, in practice, due to the existence of the "transaction cost" that Coase and Williamson point out, it is not possible to write and commit to a complete contract between the two parties in advance. Thus, in the case of one agent, the agent will obtain a percentage α of the capital stock $\widetilde{K}_2$ at the end of the second period represented by equation (1) (which is also at the same time a gross trading surplus), in subsequent negotiations. He therefore considers only the bargaining power α of the capital stock $\widetilde{K}_2$ as private revenue and determines the levels of investment in the first and second periods. His objective function at the beginning of the first period is

$$\delta \cdot \underset{\varepsilon}{E}\left[\alpha Q \cdot \widetilde{K}_2 - C(e)\right] - g(h). \tag{5}$$

and the investment levels in the first and second periods are chosen to maximize the equation (5). The equilibrium investment levels h_s and e_s satisfy the following FOCs.

$$\alpha Q = C'(e_s). \tag{6}$$

$$\delta\alpha Q = g'(h_s). \tag{7}$$

The agent can only secure a proportion α of added value generated from the investment, which creates a hold-up problem in which an agent makes only an underinvestment level from the viewpoint of the whole organization.
This means that the functioning of the (relative trading type) market is incomplete under the incomplete contract situation where transaction costs exist. The overall view of the model is that the government participates as a "player" in the institutional design of the two-stage tournament and strengthens the functioning of the innovation organization consisting of the government and two firms.[13]

3. Solution of the Model

After this, the game of the two-stage tournament is solved backwards. First, we will analyze the competitive situation in the second period (the competition situation after the first stage ranking is completed) in 3.1.

3.1 Second Period

[13] The government in this paper is a more active and proactive player than in the "Market Enhancing View" (mid-1990's) presented by Aoki et al (1996) in " The role of Government and Economic Development in East Asia".

It is assumed that the difference in technological levels reached by the agent shrinks due to the "dialogue", that is, the transfer of knowledge and technology after the ranking of the first period. Thus, even if the agents have reached different capital stock configurations, learning including R&D spillover or transfer of knowledge (intellectual assets) occurs at the end of the first period. Now, we assume that when stocks at the end of first period are $(\tilde{K}_{i1},\ \tilde{K}_{j1}),\ i \neq j$ the stock held by agent *i* at the start of the second period becomes $K_{i2}(\tilde{K}_{i1},\ \tilde{K}_{j1}) = \bar{K} + (\tilde{K}_{i1} - \bar{K}) + t(\tilde{K}_{j1} - \bar{K})$, where t is a real number, satisfying $0 \leq t \leq 1$. That is, the agent can learn the rate t of capital accumulation of his competitor.

In Japan and China, various mechanisms for collecting and exchanging information (government councils and private research groups) are established by the government, and private networks for information exchange are utilized.[14] For instance, it is well known that in the auto/parts industry, the essence of the drawings contrived by one supplier may be transferred to a rival supplier.

We simply formulate this characteristic of "controlled" competition as the following assumption.

Assumption 1: Linear Transfer Technology

The principal can offer opportunities for transfer of technology /knowledge. Through such transfers, the difference in capital stocks of the agents decreases, and the capital stock of agent i at the start of the second period is written as follows, given the end of first period stocks $(\tilde{K}_{i1},\ \tilde{K}_{j1})$,

$$K_{i2}(\tilde{K}_{i1},\ \tilde{K}_{j1}) = \bar{K} + (\tilde{K}_{i1} - \bar{K}) + t(\tilde{K}_{j1} - \bar{K}) \quad for\ i \neq j,\ and\ 0 \leq t \leq 1.$$

This assumption simply abstracts the industrial policy that the government (principal) directly and discretionarily intervenes in the process of competition between a small number of members, for example, passing on what the government has learned about the technology of private companies through industry groups.[15] Agents know the structure of this learning process (linear transfer technology) and make investments in the first period, expecting this process and its effect upon the second stage competition. The winner of the first period competition is given a favorable production allotment, as a reward both for the victory and for transferring his knowledge capital. This assumption implies that after the first period, the principal gives *an interim rank* to the two agents and then shrinks the difference between them, and due to the linearity of technology transfer, the analysis becomes simpler without fundamental changes. Later, we will investigate the effect of this knowledge (technology) transfer upon the equilibrium, and the solution of the model.

Next, the following assumption is made regarding the sharing of production profit (trade gain):

Assumption 2: When the transaction profit $(\tilde{K}_{12},\ \tilde{K}_{22})$ from the production at the end of the final fiscal period is divided, the principal and each agent negotiate *individually*. The bargaining power α at that time is given exogenously, but it is not necessarily the same.

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[14] This was confirmed also from interviews with the Chinese local government officials in 2008.

[15] Using the terminology of Nonaka and Takeuchi's "Knowledge-Creating Firms" (1995), this can be viewed as the "Implicit knowledge sharing (Socialization)" stage. The government provides a technological platform (place) for sharing each other's implicit knowledge and creating new implicit knowledge, which can lead to successful innovations.

This is because the focus of this paper is not a problem of endogeneity of bargaining power, but is concerned with how the diachronic competition between homogeneous and heterogeneous agents changes at the hand of the third party (visible hand). This bargaining power α is deeply related to the ownership structure between the enterprise (agent) and the government, and is also the distribution ratio of the transaction profit, so the larger the proportion of the SOE (private enterprise) is, the smaller (larger) α is. [16] The theoretical interest of this paper is in **both the difference in bargaining power α (ownership ratio, state-owned and private-owned enterprises) and the diachronic tournament competition**. In other words, this paper deals with an analysis of dynamic tournaments consisting of homogeneous and heterogeneous agents with various bargaining powers (ownership ratios).

3.1.1. Asymmetrical Tournaments under production allotments in the second period $\boldsymbol{\alpha_1 = \alpha_2 = \alpha}$ $\boldsymbol{(0 \leq \alpha \leq 1)}$ **case**

At the start of the second period, there exist two agents who are assigned different ranks and the ordered quantity based upon the outcome of the first period competition. We call them the winner and the loser, respectively. In this interim stage, the agents are ***no longer symmetric***, which is different from the beginning of the first period. This is because they begin their investments **given different production allotments**, as well as a possible difference in capital accumulation. Nonetheless, due to assumption 1 (transfer of technology and knowledge through "dialogue"), both agents have approached each other closely in terms of their skills. (Their accumulated capital stocks are 'modified'.) Taking this modified capital stock $(K_{12},\ K_{22})$ and its difference $K_{12} - K_{22} = (1-t) \cdot (\widetilde{K}_{11} - \widetilde{K}_{21}) \equiv \Delta K$ as given, the investment decisions in the second period are made in the form of solving the following problems independently and simultaneously.

$$V_{2W}(\alpha Q, \Delta K, \lambda, W) = \max_{e_W} \underset{\varepsilon}{E}\{\alpha \widetilde{K}_{2W} \cdot \lambda Q + \Phi(\Delta K + \Delta e) \cdot W - C(e_W)\}. \tag{8}$$

$$V_{2L}(\alpha Q, \Delta K, 1-\lambda, W) = \max_{e_L} \underset{\varepsilon}{E}\{\alpha \widetilde{K}_{2L} \cdot (1-\lambda) Q + \big(1 - \Phi(\Delta K + \Delta e)\big) \cdot W - C(e_L)\}. \tag{9}$$

Here, mathematical expressions (8) and (9) are the problems faced in the second period by the winner and the loser in the previous period, respectively. (Also note that if the participation constraint of the loser is satisfied, that of the winner will be automatically satisfied.) The meanings of equations (8) and (9) are as follows.

(1) By winning or losing the capital accumulation competition in the first period, that is, **relative ranking**, the production allotment of the production stage in the final period is assigned as follows. Let $q_i$as agent i's production

[16] The bargaining power $\alpha \in [0,1]$ of each agent, though it is exogenously given, has an important implication when interpreting the model. On the interpretation ofα, Riordan (1991) gives a specific treatment of the manufacturer-supplier relationship, and a particular kind of vertical integration: backward integration. A large downstream firm may acquire claims on small upstream firm's (supplier's) residual claims. Thus, in Riordan's terminology, $1-\alpha$ is a measure of the degree of backward integration in this paper. In Riordan, the ownership structure that optimally induces incentives for specific investments is analyzed as the optimal ownership ratio α^*

$$q_i = \begin{cases} \lambda Q & if\ \widetilde{K}_{i1} > \widetilde{K}_{j1} \\ (1-\lambda)Q & if\ \widetilde{K}_{i1} < \widetilde{K}_{j1} \end{cases}$$

where λ is the production ratio allocated to **the winner** of the previous period, and $\lambda \in (1/2, 1)$ is satisfied. This means that **the government (principal) will increase the production quantity for the winner in the previous period.** We also assume that the principal's demand for the final goods is constant as $Q > 0$.

(2) $\widetilde{K}_{2W}$, $\widetilde{K}_{2L}$ is the quality per unit of goods accumulated by the winner and loser of the first period at the end of the second period, that is, the production and sales stage. If this becomes the evaluation (valuation) of the buyer, that is, the government, as it is, and the production and sales cost is 0, it then becomes the value of the transaction actually realized, that is, the social surplus (gross).

(3) α is an exogenous parameter that represents the bargaining power of the firm,[17] reflecting the ownership structure between the government (principal) and the firm (agent). In other words, it is the share-ownership ratio of the firm, thus representing the agent's share in trading profits. In other words, $\widetilde{K}_{2W}$, $\widetilde{K}_{2L}$ is the evaluation value of the consumer (government) for the final goods in each specification, and $\alpha \cdot \widetilde{K}_{2W}$, $\alpha \cdot \widetilde{K}_{2L}$becomes the unit revenue (transaction price) for the agent.

(4) W is the future value, including the monetary prize (or subsidy) that the principal gives to the final winner of the capital accumulation competition, that is, to the larger agent of $\widetilde{K}_{2W}$ and $\widetilde{K}_{2L}$. For a manager of an SOE, it will be a future value that includes the promotion value of winning the competition.

(5) $\Phi(\Delta K + \Delta e)$ is the probability that the winner of the previous period wins again in the second period of the capital accumulation competition, given the difference ΔK between the two agents, thereby obtaining the prize W. This is a function of (the difference between) the investment levels of the two agents $\Delta e = e_w - e_L$.

Now, the probability Φ that the winner of the previous period wins again in the second period is given by the following equation (10).

$$\Phi(\Delta K + \Delta e) \equiv Prob\left(\widetilde{K}_{2W} > \widetilde{K}_{2L}\right) = Prob(\Delta K + e_w - e_L > \varepsilon_L - \varepsilon_W) = \Phi(\Delta K + e_w - e_L). \qquad (10)$$

Here Φ is a distribution function of the random variable$\varepsilon_L - \varepsilon_W$, and the density function is assumed to be a lower case ϕ. In addition, the density function ϕ has support $[-\bar{\varepsilon},\ \bar{\varepsilon}]$, and is symmetric within that range, and is a decrease function for $\varepsilon_L - \varepsilon_W = \chi > 0$. That is,

$$\phi(\chi) = \phi(-\chi)\ \ for\ \forall\chi \in [-\bar{\varepsilon},\ \bar{\varepsilon}] \quad \text{and} \quad \phi'(\chi) < 0\ \ for\ \chi > 0.$$

Now, the FOCs for the problems of the agents (winner and loser) in the second period are

$$\alpha \cdot \lambda \cdot Q + \frac{\partial\Phi(\Delta K + e_w - e_L)}{\partial e_W} \cdot W - C'(e_W) = 0. \qquad (11)$$

$$\alpha \cdot (1-\lambda) \cdot Q - \frac{\partial\Phi(\Delta K + e_w - e_L)}{\partial e_L} \cdot W - C'(e_L) = 0. \qquad (12)$$

In other words, the solution of equations (13) and (14) represents the Nash equilibrium of the second period under the production allotment.

$$\alpha \cdot \lambda \cdot Q + \phi(\Delta K + e_w - e_L) \cdot W - C'(e_W) = 0. \qquad (13)$$

$$\alpha \cdot (1-\lambda) \cdot Q + \phi(\Delta K + e_w - e_L) \cdot W - C'(e_L) = 0. \qquad (14)$$

---

[17] The terms "firm, company, and enterprise" appearing through this paper all have the same meaning.

Here, the first terms of the formulas (13) and (14) show the marginal revenue of the (ex post) capital accumulation, given the assigned production allotments. The second terms show the marginal value products of the second period investments, through the marginal improvement of the probability of obtaining the monetary prize (subsidy) W. To ensure the existence of an optimum in the second period problem, we assume that the following second order conditions (SOCs) are satisfied.

$$\phi'(\Delta K + e_w - e_L) \cdot W - C''(e_W) < 0.$$
$$-\phi'(\Delta K + e_w - e_L) \cdot W - C''(e_L) < 0.$$

[Proposition 1]. The Case of $\boldsymbol{\alpha_1 = \alpha_2 = \alpha}$

At the equilibrium of the second period investment competition, the leading firm (the winner in the first period) ***never invests less than*** *the follower (the loser in the first period). (Existence of* ***Asymmetric Equilibrium****.)*

〔**Proof**〕

To compare the incentives of both agents, we take the difference between equations (13) and (14), and obtain

$$C'(e_w) - C'(e_L) = (2\lambda - 1) \cdot \alpha \cdot Q. \qquad (15)$$

Since $\alpha \geq 0$, $Q > 0$, $\lambda > 1/2$ and C' is increasing in e, regarding the amount of equilibrium investments, we immediately obtain $e_W^* \geq e_L^*$. (16) Q. E.D.

According to the ranking based upon the outcome of the first period competition, a difference between the shares in the production at the end of the second period $\lambda - (1 - \lambda) = 2\lambda - 1$ is imposed, resulting in the difference of $(2\lambda\text{-}1)\alpha Q$ in the marginal productivities of investment in the second period. This generates the asymmetric equilibrium that arises in the second period, and from (16), the winner exerts more effort than the loser does at equilibrium (when $\lambda = 1/2$, it follows that $e_W^* = e_L^*$).

Let us investigate the above results, from the viewpoint of "***strategic substitutability and complementarity***". Differentiating (13) and (14) representing the Nash equilibrium as to e_L and e_w, respectively, we obtain the following effects on the marginal profitability,

$$-\phi'(\Delta K + e_W^* - e_L^*) \cdot W > 0. \qquad (17)$$
$$\phi'(\Delta K + e_W^* - e_L^*) \cdot W < 0. \qquad (18)$$

That is, in the neighborhood of the second period equilibrium, the investments are ***strategic complements*** **for the winner**, and ***strategic substitutes*** **for the loser**. This implies that these **two agents react differently** when $\frac{1}{2} < \lambda < 1$. The reaction function of the leading firm (the winner) is increasing in the follower's (the loser's) effort, whereas the reaction function of the trailing firm (follower) is decreasing in the leader's (the winner's) effort. The figure below suggests that the leading firm has more incentive to invest (*becomes aggressive*) when it faces intense competition by the follower, whereas the trailing firm has more incentive to invest when the winner (rival) becomes *less aggressive.*

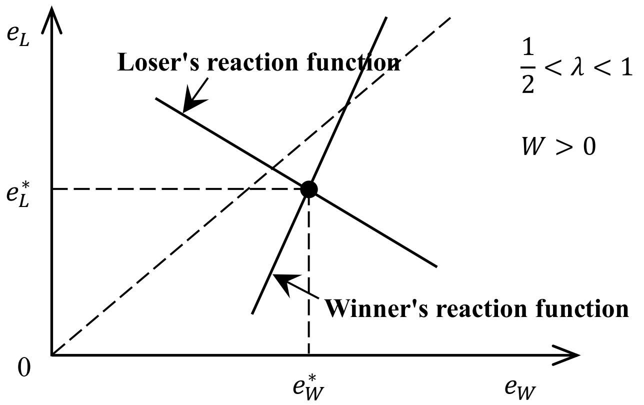

Figure 2. 1 Equilibrium in the Second Period

3.1.2. Comparative Statics on the second period Nash Equilibrium: The Effects of W, λ and t, α

In addition, we obtain the propositions examining the comparative statics on how the Nash equilibrium in the second period changes with the increase in W and λ.

[Proposition 2].

An increase in the size of the prize (subsidy) W induces an increase in both agents' incentives, but the difference between them decreases. In other words, the marginal incentive for investment increases more greatly for the loser than for the winner. That is,

$$\frac{\partial e_W^*}{\partial W} > 0, \ \frac{\partial e_L^*}{\partial W} > 0, \frac{\partial (e_W^* \text{-} e_L^*)}{\partial W} \leq 0, \tag{19}$$

[Proof]

Differentiating equations (FOCs) (13) and (14) and setting $d\lambda = d\alpha = 0$, we obtain the following matrix representation.

$$\begin{bmatrix} \phi' \cdot W\text{-}C''(e_W) & \text{-}\phi' \cdot W \\ \phi' \cdot W & \text{-}\phi' \cdot W\text{-}C''(e_L) \end{bmatrix} \begin{bmatrix} \frac{\partial e_W^*}{\partial W} \\ \frac{\partial e_L^*}{\partial W} \end{bmatrix} = \begin{bmatrix} \text{-}\phi \\ \text{-}\phi \end{bmatrix}.$$

Here, we check whether the stability condition is satisfied. Let the Hessian determinant be $|D|$. Then,
$|D| = (\phi' \cdot W\text{-}C''(e_W))(\text{-}\phi' \cdot W\text{-}C''(e_L)) + (\phi' \cdot W)^2 > 0.$
The positive sign was derived from the SOCs and the conditions on Φ and C.
Solving the matrix systems by using Cramer's Rule, we can obtain

$$\frac{\partial e_W^*}{\partial W} = \frac{|D_1|}{|D|} = \frac{\phi C''(e_L^*)}{|D|} > 0, \qquad \frac{\partial e_L^*}{\partial W} = \frac{|D_2|}{|D|} = \frac{\phi C''(e_W^*)}{|D|} > 0.$$

Considering the difference in equilibrium incentives, we have

$$\frac{\partial (e_W^* - e_L^*)}{\partial W} = \frac{|D_1| - |D_2|}{|D|} = \frac{\phi(C''(e_L^*) - C''(e_W^*))}{|D|} \leq 0.$$

This result is obtained from $C''' \geq 0,\ e_W^* \geq e_L^*$, and $|\mathrm{D}| > 0$. **Q.E.D.**

In order to understand this result intuitively, it is necessary to remember that the prize (subsidy) in the second period is given to the final winner, based upon the final rank irrespective of the interim rank of the capital accumulation competition. From the FOCs (13) and (14), an increase in the prize W implies an increase in the marginal value products for both agents. Thus, it has a positive effect upon the second-period investments of both agents. It should be noted that the marginal revenue for each agent through the increase in W is the same value, $\Phi(\Delta\mathrm{K} + \mathrm{e_w}\text{-}\mathrm{e_L})$. Noticing that the winner has more investments in equilibrium, $\mathrm{e}_\mathrm{W}^* \geq \mathrm{e}_\mathrm{L}^*$, the same marginal revenue induces more incentive from the loser, under the convexity of the cost function in effort incentive.[18] We recognize from this fact that the increased subsidy in the second period shrinks the difference between the equilibrium incentives of two agents. (Figure 2 2)

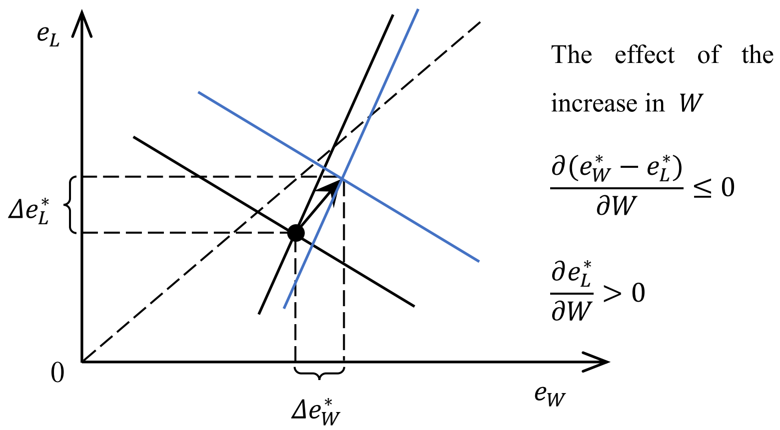

Fig. 2.2 Effect of increase *in* W on equilibrium

[Corollary 1]

We assume that $\mathrm{C(e)} = 1/2\mathrm{e}^2$. *In this case, using the FOCs (13) and (14), the equilibrium investment levels are* $\mathrm{e}_\mathrm{W}^* = \alpha\lambda\mathrm{Q} + \phi^* \cdot \mathrm{W},\ \mathrm{e}_\mathrm{L}^* = \alpha(1\text{-}\lambda)\mathrm{Q} + \phi^* \cdot \mathrm{W}$,*where* $\phi^* = \phi(\Delta\mathrm{K} + \mathrm{e}_\mathrm{W}^*\text{-}\mathrm{e}_\mathrm{L}^*) = \phi(\Delta\mathrm{K} + \alpha \cdot (2\lambda\text{-}1))$.

Then, by the statements of formula (11), $\frac{\partial \mathrm{e}_\mathrm{W}^*}{\partial \mathrm{W}} = \frac{\partial \mathrm{e}_\mathrm{L}^*}{\partial \mathrm{W}} = \phi > 0, \frac{\partial(\mathrm{e}_\mathrm{W}^*\text{-}\mathrm{e}_\mathrm{L}^*)}{\partial \mathrm{W}} = 0.$

The implication is that, the increased prize W of the second period has a positive effect upon the equilibrium investment of each agent, but in the "quadratic" cost function case, the size of the effort increase is the same, and so, the difference between effort incentives remains unchanged. On the other hand, as proposition 2 shows, in the case

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[18] Concavity of the marginal cost function $C' > 0, C'' > 0, \boldsymbol{C''' \leq 0}$ will bring about $\partial(e_W^* - e_L^*)/\partial W \geq 0$, that is, the marginal incentive for investment increases **more greatly for the winner**.

of $C(e) = \frac{R}{2}e^{\beta}$, where $\beta > 2$ and $R > 0$, e_W^*-e_L^* decreases as W increases. [19]

Next, we check the effect of increasing technology (information) transfer t on the second period equilibrium.

[Corollary 2]

The investment levels at the competition equilibrium in the second period increase as $t \to 1$. *From equations (13) and (14), the difference in investment levels between the two is the same. Since* $\Delta K = (1-t)\cdot(\widetilde{K}_{11} - \widetilde{K}_{21})$ *is the modified difference, the difference between the two increases as* t *shifts closer to 0. Then, the marginal productivity (probability density)* $\phi(\Delta K + e_W^* - e_L^*)$ *decreases, and therefore both* e_W^* *and* e_L^* *decrease. When* t *is closer to 1, it reversely increases both* e_W^* *and* e_L^*.

As next comparative statics, we can obtain the effect of the increased λ, that is, the increase in supply market share to the winner of the previous period upon the equilibrium incentives in the second period.

[Proposition 3].

The effect of the change in λ *upon the Nash equilibrium in the second period is as follows.*

$\frac{\partial e_W^*}{\partial \lambda}$? $\frac{\partial e_L^*}{\partial \lambda} < 0$ $\frac{\partial (e_W^* - e_L^*)}{\partial \lambda} > 0$ $\frac{\partial (e_W^* + e_L^*)}{\partial \lambda} < 0$ *and then* $\frac{\partial[\lambda e_W^* + (1-\lambda)e_L^*]}{\partial \lambda} = (e_W^* - e_L^*) + \lambda\frac{\partial (e_W^* - e_L^*)}{\partial \lambda} + \left(\frac{\partial e_L^*}{\partial \lambda}\right)$?

[Proof]

Differentiating FOCs (13) and (14) and setting $d\alpha = dt = dW = 0$, we obtain the following matrix representation.

$$\begin{bmatrix} \phi'\cdot W - C''(e_W) & -\phi'\cdot W \\ \phi'\cdot W & -\phi'\cdot W - C''(e_L) \end{bmatrix} \begin{bmatrix} \frac{\partial e_W^*}{\partial \lambda} \\ \frac{\partial e_L^*}{\partial \lambda} \end{bmatrix} = \begin{bmatrix} -\alpha Q \\ \alpha Q \end{bmatrix}.$$

We have already checked the stability condition and the Hessian determinant $|D| > 0$. Solving the matrix systems by using Cramer's Rule, we can obtain:

$$\frac{\partial e_W^*}{\partial \lambda} = \frac{\alpha Q[2\phi' W + C''(e_L)]}{|D|} ? \quad \frac{\partial e_L^*}{\partial \lambda} = \frac{\alpha Q[2\phi' W - C''(e_W)]}{|D|} < 0.$$

$$\frac{\partial (e_W^* - e_L^*)}{\partial \lambda} = \frac{\alpha Q[C''(e_W^*) + C''(e_L^*)]}{|D|} > 0.$$

$$\frac{\partial (e_W^* + e_L^*)}{\partial \lambda} = \frac{\alpha Q(4\phi' W - [C''(e_W^*) - C''(e_L^*)])}{|D|} < 0.$$

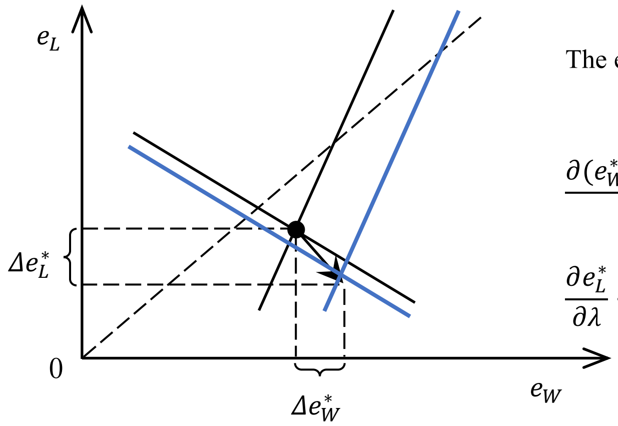
where SOC s $\phi' W - C''(e_W) < 0$,$-\phi' W - C''(e_L) < 0$ and $C''' \geq 0$ are used when four signs are derived.

Q.E.D.

This implies that an increase of λ (the volume of allotment assigned to the winner) discourages the loser greatly after its implementation, whereby **the difference between equilibrium incentives increases**. This is in contrast with

[19] We find that in the case of $C(e) = \frac{1}{2}e^{\beta}$, where $1 < \beta < 2$, e_W^*-e_L^* increases as W increases.

the results on the effect of W. As for **the winner's incentive**, this is a bit involved. The increase in the volume of assigned allotment λ generally increases the investment incentives holding the other's investment fixed. However, when both the winner and the loser invest, **shifting (transferring) more λ from the loser to the winner** moves **the winner's best response function** $e_W^*(e_L;\lambda,W)$ **outward**, but at the same time, **moves the loser's best response curve $e_L^*(e_W;\lambda,W)$ downward (inward)**. Thus, the **Milgrom-Roberts Theorem (1990) cannot be applied**. As the computation result shows, we don't know for sure whether the winner's equilibrium incentive $e_W^*(e_L;\lambda,W)$ increases or not, since **feedback from decreased e_L** can be so strong as to override the direct effect by the increase of λ.[20] (Nonetheless, we can say for sure that the equilibrium e_L^* goes down, because **the direct effect and the feedback effect work in the same direction, i.e. that of decreasing** e_L^*.) Regarding these contrastive incentive effects of λ and W, compare the two figures 2-3 and 2-4.



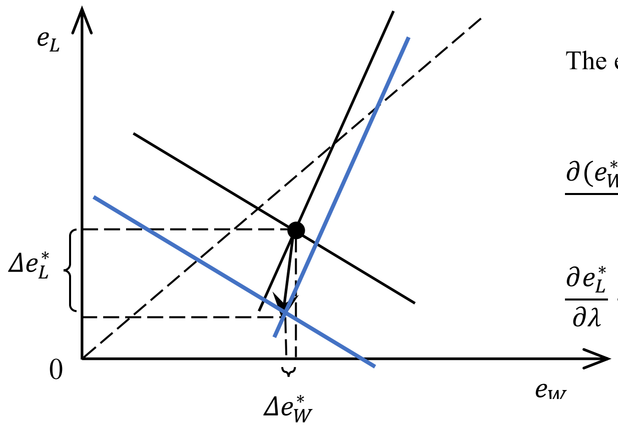
The effect of the increase in λ

$$\frac{\partial(e_W^*-e_L^*)}{\partial\lambda}\geq 0$$

$$\frac{\partial e_L^*}{\partial\lambda}<0$$

Fig. 2.3 Effect of increase in λ on equilibrium

The Case **where Direct effect is greater.**



The effect of the increase in λ

$$\frac{\partial(e_W^*-e_L^*)}{\partial\lambda}\geq 0$$

$$\frac{\partial e_L^*}{\partial\lambda}<0$$

Figure 2.4 Effect of increase in λ on equilibrium:

The Case **where Feedback effect is greater.**

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20 By interpreting $(\lambda, 1-\lambda)$ as an asset ownership structure, we see that the comparative statics result on the effect of increasing λ is quite similar to that on the change of asset ownership in Hart-Moore (1990).

The final term in proposition 3 represents the way in which weighted average $\lambda e_W^* + (1-\lambda)e_L^*$ of the equilibrium incentives is affected by a marginal change in λ. The sign is ambiguous because the first and second terms are positive, but the third term is negative. Thus,

[Proposition 4].

An increase in the bargaining power $\boldsymbol{\alpha}$ *of each agent unambiguously increases the second period equilibrium incentive of the winner, but its effect is ambiguous for the second period equilibrium incentive of the loser.*

[Proof]

Differentiating FOCs (13) and (14) and setting $d\lambda = dW = dt = 0$, we obtain the following matrix representation.

$$\begin{bmatrix} \phi' \cdot W - C''(e_W) & -\phi' \cdot W \\ \phi' \cdot W & -\phi' \cdot W - C''(e_L) \end{bmatrix} \begin{bmatrix} \frac{\partial e_W^*}{\partial \alpha} \\ \frac{\partial e_L^*}{\partial \alpha} \end{bmatrix} = \begin{bmatrix} -\lambda Q \\ -(1-\lambda)Q \end{bmatrix}.$$

We have already checked the stability condition and the Hessian determinant $|D| > 0$. Solving the matrix systems by using Cramer's Rule, we can obtain

$$\frac{\partial e_W^*}{\partial \alpha} = \frac{\lambda Q\big(\phi' W + C''(e_L)\big) - (1-\lambda)Q\phi' W}{|D|} > 0.$$

$$\frac{\partial e_L^*}{\partial \alpha} = \frac{-(1-\lambda)Q\big(\phi' \cdot W - C''(e_W)\big) + \lambda Q\phi' W}{|D|} \quad ?$$

This result implies that **an increase in $\boldsymbol{\alpha}$** might have **an asymmetric incentive effect for both the winner and the loser** at equilibrium. Indeed, when λ is close to 1, the best response function of the winner shifts outward even more than the loser's one. Then, $\frac{\partial e_L^*}{\partial \alpha} < 0$ holds at equilibrium. This is the case where the **positive direct effect on the loser's incentive $\boldsymbol{e_L^*}$** by the increase of $\boldsymbol{\alpha}$ is completely **overridden by the negative feedback from increased $\boldsymbol{e_W}$** [21].

3.1.3 Summery

From the above, the expected profits that the winner and loser of the first period obtain at the asymmetric equilibrium of the second period are as follows.

$$\boldsymbol{V_{2W}^*} = \alpha \cdot \lambda \cdot Q(K_{i2} + e_W^*) + \Phi \cdot W - C(e_W^*). \qquad (20)$$

$$\boldsymbol{V_{2L}^*} = \alpha \cdot (1-\lambda) \cdot Q \cdot (K_{i2} + e_L^*) + (1-\Phi) \cdot W - C(e_L^*). \qquad (21)$$

Here, $\Phi(\Delta K + e_W^* - e_L^*) \geq \frac{1}{2}$ and $K_{i2} = \overline{K} + (h_i + \varepsilon_i) + t(h_j + \varepsilon_j)$.

Therefore, **the difference in equilibrium profits** is

$$\Delta V^*(\alpha Q, K_{i2}, \lambda, W) = \alpha \cdot (2\lambda - 1) \cdot Q \cdot K_{i2} + \{\alpha Q \cdot [\lambda e_W^* - (1-\lambda)e_L^*] + (2\Phi - 1) \cdot W - [C(e_W^*) - C(e_L^*)]\}. \quad (22)$$

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[21] Notice that e_L and e_W are ***strategic substitutes* for the loser**, such that there exists a negative feedback relationship where e_L decreases against the increase in e_W.

This is a **discrete prize**, which positively induces ex-ante (first period) incentives from the agents when $\lambda > 1/2$, and this prize establishes the ex-ante competition. Let us summarize the mechanism, which has worked thus far in the model. The principal announces and commits herself to an incentive scheme, where the principal evaluates agents based upon the interim ranking (relative performance) of the outcome of the first period competition, and then discretely changes the production share to favor the winner. Thereby, when the two agents (the leader and the follower) compete for the monetary prize in the second period, there exists an asymmetric equilibrium due to the difference in the marginal productivities, resulting in a difference between the equilibrium profits of the two agents. This in turn works as a carrot (prize), which enhances the ex-ante incentives of the two agents. Therefore, when $\lambda > 1/2$, the agents are faced with the tournament scheme that has the prize shown in (22), where the reward is discontinuously based upon his performance (see Figure 3). This is the essential logic of the analysis so far.[22] The global incentive constraint in the second period (interim individually rationality constraint) will be investigated later.

3.2 The First Period: Equilibrium of the First period in the Game of Homogeneous Agents ($\boldsymbol{\alpha_1 = \alpha_2 = \alpha}$)

At the start of the 0-period, the principal is faced with homogeneous agents with a capital stock level $\overline{K}$. She announces an organizational structure (incentive scheme), which consists concretely of the rule for the production allotment in the final period and the rule of competition for the monetary prize. The former is related to whether the principal endogenously chooses a non-elimination tournament $\lambda \neq 1$,where the loser is not eliminated and is given one more chance in the second period, or the elimination tournament $\lambda = 1$, where the loser is forced to drop out of the race in the second period.

After accepting the contract, the two agents choose the capital investment levels of the first period in such a way as to maximize their own expected payoffs. Now, we suppose that the capital stock of agent i at the end of the first period is $\widetilde{K}_{i1} = \overline{K} + h_i + \varepsilon_i \qquad i = 1, 2.$ (23)

$\overline{K}$is the capital stock at the start point, observable among the principal and the two agents. h_i is the investment level during the first period. ε_i is the uncertainty factor (the random shock in the first period, with no lasting value). Next, we suppose that $F(h)$, where $h = h_i - h_j$, is the probability of agent i winning in the first period competition. Then, $F = Prob(\widetilde{K}_{i1} > \widetilde{K}_{j1}) = Prob(h_i - h_j > \varepsilon_j - \varepsilon_i) = F(h_i - h_j)$. (24)

$\varepsilon_j - \varepsilon_i$is the difference between the noise ε_i and ε_j and F is the distribution function of the random variable $\varepsilon_j - \varepsilon_i$. From the analysis in the former section, we see that the two agents are faced with the following tournament scheme.

$$S^i(\widetilde{K}_{i1},\ \widetilde{K}_{j1}) = \begin{cases} V_{2L} & \text{if } \widetilde{K}_{i1} < \widetilde{K}_{j1} \\ V_{2L} + \Delta V & \text{if } \widetilde{K}_{i1} > \widetilde{K}_{j1} \end{cases}$$

If an agent wins the race in the first period, he can obtain ***the discrete prize*** $\boldsymbol{\Delta V}$ in addition to the base value V_{2L}

[22] From the perspective of **the role of government in economic development** in Aoki, et al. (1996). this prize is **the "quasi-rent" created by government policies (institutional design)**, and competition between rivals will occur for the acquisition of this rent, which creates the motivation to improve quality.

The reward to be obtained by agent i is based upon his absolute performance $\widetilde{K}_{i1}$ **discontinuously**. See **Figure 3**. This differs from the relative performance scheme where the reward is based upon his absolute performance $\widetilde{K}_{i1}$ continuously. The important point of this scheme is **the discontinuity**, rather than the non-concavity, because it generates the basis for establishing the ex-ante fierce competition between agents.

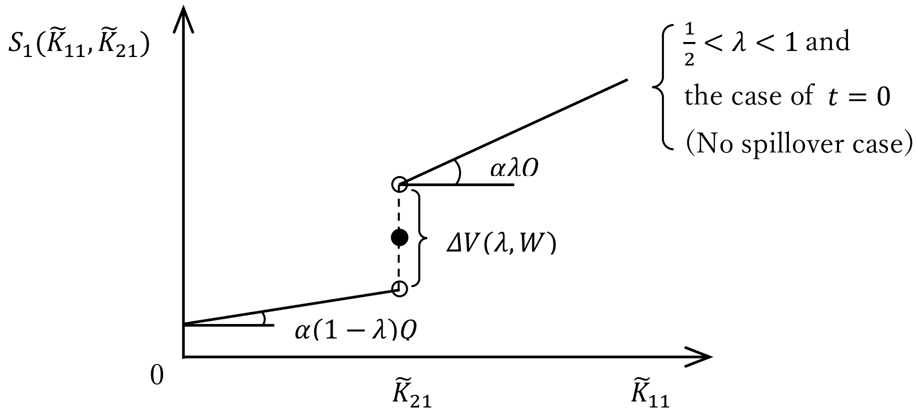

Figure 3 Tournament Scheme Faced by Agent 1 in the First Period.

The two agents solve the following problems simultaneously and independently, given the rival's investment h_j .

$$\max_{h_i} \delta \cdot \underset{\varepsilon}{E}\{F(h) \cdot V_{2W}^* + (1 - F(h)) \cdot V_{2L}^*\} - g(h_i). \tag{25}$$

The fundamental equation of this problem, given h_j, is

$$V_i(K_o, K_o) = \max_{h_i} \delta \cdot \{V_{2L}^* + F(h) \cdot \Delta V^*\} - g(h_i) \qquad i = 1, 2\,. \tag{26}$$

The first term V_{2L}^* represents the value, which the loser obtains at the Nash equilibrium in the second period, when she loses in the first period competition, given ΔK, λ and W (the principal's two instruments). The second term $F(h) \cdot \Delta V^*$ is the expected prize, which implies that with the probability of $F(h)$, the agent can receive this lump sum prize ΔV^* , which is **endogenously generated as the equilibrium payoff difference in the second period** through the incentive scheme λ and W. $g(h_i)$ is the cost function of investment h_i, with $g' > 0,\ g'' \geq 0$. We shall now define $\bar{v}$ and $\underline{v}$ as follows.

$$\bar{v} = \bar{v}(\alpha, Q, \lambda, W) = \alpha\lambda Q e_W^* + \Phi \cdot W - C(e_W^*).$$

$$\underline{v} = \underline{v}(\alpha, Q, (1-\lambda), W) = \alpha(1-\lambda)Q e_L^* + (1-\Phi) \cdot W - C(e_L^*).$$

where $\Phi = \Phi(\Delta K + e_W^* - e_L^*) \geq 1/2$ (the equality is satisfied when $\lambda = 1/2$ and $\Delta K = 0$).

Solving the problem, we can obtain the FOC for agent 1.

$$\delta \cdot \{\alpha(1-\lambda)Q \cdot 1 + F(h_1 - h_2)[(2\lambda - 1)\alpha Q \cdot 1 + 2(1-t)\phi(\Delta K + e_W^* - e_L^*)W] \\ +[(2\lambda - 1)\alpha Q K_{12} + \bar{v} - \underline{v}]f(h_1 - h_2)\} = g'(h_1). \tag{27}$$

where $K_{12} = \overline{K} + (h_1 + \varepsilon_1) + t \cdot (h_2 + \varepsilon_2)$ implies that the right-hand side (RHS), consisting of the initial stock $\overline{K}$ plus the capital accumulation h_1 by agent 1 plus the rate of t of the accumulation h_2 by the rival agent leads to the modified stock level K_{12} (Left-Hand Side, LHS) at the start of period 2. Similar conditions can also be obtained for agent 2.

The equation (27) implicitly defines **the reaction function of agent 1 in the first stage**. Similar conditions can be obtained with respect to agent 2. Since both agents have the same assets at the beginning of the first period and the bargaining power (ownership ratio) α is also the same, they are thus both players of "homogeneity". Hence, in a symmetric equilibrium, the incentives are $h_1^* = h_2^* = h^*(\lambda, W; \alpha, t)$.

In this case, the FOCs are simplified as follows, characterizing the symmetric subgame perfect Nash equilibrium investment level.

$$\begin{aligned}\delta \cdot \{\alpha(1-\lambda) \cdot Q \cdot 1 + F(0) \cdot [(2\lambda - 1) \cdot \alpha Q + 2(1-t)\phi(e_W^* - e_L^*)W] \\ +[(2\lambda-1)\alpha Q(\bar{K} + (1+t) \cdot h^*) + \bar{v} - \underline{v}] \cdot f(0)\} = g'(h^*). \qquad (28)\end{aligned}$$

The three terms on the LHS represent the following effects. The first term represents the marginal increase in the value V_{2L}^* (formula (21)) that is expected to be obtained at the second period Nash equilibrium, when the agent loses in the first period competition, through the increase in capital investment in the first period. The second term represents **the marginal increase in the discrete prize**: $V_{2W}^* - V_{2L}^*$ itself, with the probability of winning being $F(0) = 1/2$ at equilibrium. The two terms in the bracket of the second term are, respectively, *the direct effect* and *the marginal strategic effect*. The direct effect means the (private) marginal revenue from the increase in the ordered quantity$(2\lambda - 1)$,with equal probability in equilibrium. ***The marginal strategic effect*** $2F(0) \times 2(1-t)\phi(e_W^* - e_L^*)W = (1-t)\phi(e_W^* - e_L^*)W$ implies a strategic incentive for the agents to increase marginally the probability of winning in the final period through increasing the difference in the first period capital accumulation. The third term is ***the tournament effect*** through marginal improvement of the probability of winning, given the equilibrium payoff difference, that is, the discrete prize. By summing up the two direct effects, the FOCs (Local Incentive Constraints) are transformed as follows.

$$\delta \cdot \{{}^1/_2\, \alpha \cdot Q + (1-t)\phi(e_W^* - e_L^*)W + [(2\lambda-1)\alpha Q(\bar{K} + (1+t)h^*) + \bar{v} - \underline{v}]\, f(0)\} = g'(h^*). \qquad (28')$$

“Direct effect”, “Strategic effect” and “Tournament effect” are all positive.

Further, in this two-stage game, the global incentive constraint must be satisfied in the ex-ante stage at the first period symmetric equilibrium. The agents can choose an alternative to deviate from the intense competition, becoming contented with the position of the loser in the tournaments, and thus they can obtain the following intertemporal payoff.[23]

$$\begin{aligned}U &= \max_{h_i}\{\delta \cdot V_{2L}^* - g(h_i)\} \\ &= \delta\{\alpha \cdot (1-\lambda) \cdot Q \cdot (\bar{K} + h_L + t \cdot h^*) + \underline{v}\} - g(h_L). \qquad (29)\end{aligned}$$

where h_L is the maximand of the above formula (29). Each agent can secure at least the payoff of $\underline{v}$ by choosing the level of h_L when the rival may choose h^*.

Now, let us check the "global incentive constraint" in the first period.[24]

[23] We assume that the random error is not a large shock, such that a firm cannot win only through luck when it exerts the level h_L and the rival exerts the level h^*. This is consistent with the other assumptions and results of the model.

[24] The ex-ante individual rationality constraint is $\frac{\delta}{2}\{V_{2W}^* + V_{2L}^*\} - g(h^*) \geq 0$. When the above global incentive constraint is satisfied, this inequality is always satisfied, since we suppose that U is strictly positive.

$$\frac{\delta}{2}\{V_{2W}^{*}(h^{*},h^{*})+V_{2L}^{*}(h^{*},h^{*})\}-g(h^{*})\geq U \tag{30}$$

$$\Leftrightarrow \frac{\delta}{2}\left\{\alpha Q\cdot(\bar{K}+(1+t)\cdot h^{*})+\alpha Q[\lambda e_{W}^{*}+(1-\lambda)e_{L}^{*}]+\frac{1}{2}W-\frac{1}{2}[C(e_{W}^{*})+C(e_{L}^{*})]\right\}-g(h^{*})$$

$$\geq U=\delta\left[\alpha(1-\lambda)Q\cdot(\bar{K}+h_{L}+th^{*})+\underline{v}\right]-g(h_{L})$$

$$=\delta[\alpha(1-\lambda)Q\{(\bar{K}+h_{L}+th^{*})+e_{L}^{*}\}+(1-\Phi(\Delta K+e_{W}^{*}-e_{L}^{*}))\cdot W-C(e_{L}^{*})]-g(h_{L}).$$

Putting this inequality in order, we obtain

$$\frac{\alpha\delta}{2}Q[\bar{K}+(1+t)h^{*}]+\frac{\delta}{2}(\bar{v}+\underline{v})-g(h^{*})\geq\alpha\delta Q(1-\lambda)(\bar{K}+h_{L}+t\cdot h^{*})+\delta\underline{v}-g(h_{L})\,. \tag{31}$$

Hence, we obtain the following proposition 5 regarding the (ex-ante) global incentive constraint.

[Proposition 5]. *The Global Incentive Constraints in the first period.*
There exists a symmetric equilibrium h^{*} *above the level of* h_{L} *in the first period only if*

$$\delta\cdot\left[\frac{\alpha Q}{2}(\bar{K}+(1+t)h^{*})+\frac{1}{2}(\bar{v}-\underline{v})-\alpha Q(1-\lambda)(\bar{K}+h_{L}+t\cdot h^{*})\right]\geq g(h^{*})-g(h_{L}). \tag{32}$$

The first term in the bracket of the LHS of (32); $\frac{\alpha Q}{2}(\bar{K}+(1+t)h^{*})$ represents the expected revenue to be obtained from the first period capital accumulation, since the agents can obtain one-half of the total allotment Q in expectation, under which they accumulate the capital $(\bar{K}+(1+t)h^{*})$ in the first period per unit of the allotment, of which they receive the share α due to their bargaining power. The second term in the brackets is the expected prize given the probability of winning in equilibrium (the payoff spread $(\bar{v}-\underline{v})$ generated in the asymmetric equilibrium in the second period, due to the policy on production allotment to the agents). The RHS is the extra cost when an agent chooses the equilibrium investment level h^{*}, not the default level h_{L}, given the rival's investment behavior of choosing h^{*}.

We can interpret proposition 5 clearly, including the interpretation of the third term of the LHS, in terms of the incentive constraint in finitely repeated games [25]. In the LHS, the second term shows that the agent can obtain the prize of $\bar{v}-\underline{v}$ with probability 1/2, if he plays the equilibrium level h^{*}, when the opponent (rival) plays h^{*}. Nonetheless, if he deviates from h^{*} to h_{L}, he loses with certainty, obtaining the allotment $(1-\lambda)$, under which he receives the share α of the total quality (gross gain from trade), consisting of his investment h_{L} generated through the first period capital accumulation, and t times the rival's larger investment h^{*}. If the agent had invested the equilibrium level of h^{*}, he would have obtained a larger benefit from his own capital accumulation itself through gaining the larger allotment, even with the probability of one-half.

The sum of these three terms is <u>*the continuation loss*</u> of deviating from h^{*} to h_{L} in the first period. It is a 'penalty' imposed upon first period shirking (deviation) in terms of the second period payoff. On the other hand, the RHS represents the cost saving of the investment due to the deviation ('shirking' or 'cheating'). This is <u>*the deviation incentive*</u>. Therefore, **if the continuation loss is larger than the deviation incentive**, then the investment level h^{*}

[25] See, for example, Benoit, P and V, Krishna (1985).

can be supported as a subgame perfect equilibrium in the first period.

Now, when condition (32) is satisfied, we can compare the local (marginal) incentive in the first period on the equilibrium path with that in the case where only one agent is the trading partner. In **the case of one agent ('bilateral monopoly')**, the agent is given the rate α of the end of second-period capital stock $\widetilde{K}_2$ represented by (1), which is equivalent to the gross total value of trade. In other words, the agent considers his bargaining power equivalent of the capital stock $\widetilde{K}_2$, as private revenue, when he decides the first and second period investments. His objective function at the beginning of the first period was described as

$$\delta \cdot \underset{\varepsilon}{E}\left[\alpha Q \cdot \widetilde{K}_2 - C(e)\right] - g(h). \tag{5}$$

He chooses the first period and the second period investment levels in such a way as to maximize formula (5). The equilibrium investment level e_s and h_s satisfy the following FOCs.

$$\alpha Q = C'(e_s). \tag{6}$$

$$\delta\alpha Q = g'(h_s). \tag{7}$$

From these, we can recognize the following facts. First, the agent underinvests in the view of the whole organization, because he can obtain only a small part of the value added which he generates through his investment. This is the so called the ***"Hold up problem"*** (or more generically, **the Free Rider Problem**). In the case where two agents compete over two periods, the equilibrium incentive in the first period is characterized by the FOC (28'). Comparing the FOCs in the two cases, first, there exists a difference in the size of the direct effect of capital accumulation, $\alpha\delta Q - \frac{1}{2}\alpha\delta Q = \frac{1}{2}\alpha\delta Q.$ (33)

Next, let us consider the marginal strategic effect $(1-t)\phi(e_W^* - e_L^*)W$. This implies an incentive for the agents to increase marginally the probability of winning in the final period through marginally increasing the difference in the end of the first period capital stocks as compared to the rival agent. This effect does not exist in the one supplier case (monopoly case). The tournament effect has the following implication. In the case of the competition for the allotment in the production "cartel", the allotment in the final stage (production and sales stage) is based upon the ranking (the rank order) of the capital accumulation in the first period. Under such an allotment mechanism, when an agent achieves larger capital accumulation and wins the race, he obtains a relatively large allotment that implies a favorable position for the ex-post competition in the second period, whereby he can obtain the additional expected profit in equilibrium. He rationally expects this prize, and will compete with his rival "head-to-head" to increase the probability of obtaining it. The indirect incentive effect resulting from this behavior is the **"tournament"** effect. We compare the relative size of these three effects, obtaining the following proposition on the ex-ante marginal (local) incentive in equilibrium.

[Proposition 6]: Comparison between marginal incentives

Suppose that there exists a unique symmetric equilibrium in the first period, i.e., the inequality (32) in proposition 5 as well as the local conditions in (28) are satisfied. The equilibrium incentive h^* *is then larger than* h_s *(the investment level in the one supplier case) if and only if*

$$\underbrace{(1-t)\phi(e_W^* - e_L^*)W}_{Marginal\,Strategic\,Effect} + \underbrace{f(0)\{\alpha Q[2\lambda - 1]\cdot[\overline{K} + (1+t)h_s] + [\bar{v} - \underline{v}]\}}_{Discrete\,Tournament\,Effect} > \underbrace{1/2\alpha Q}_{Direct\,Effect}\;. \tag{34}$$

The important element is ***the tournament effect*** as the second term of the LHS, which consists of the components. One is the term $f(0)$, which implies the marginal improvement of the probability of winning at the symmetric equilibrium. The other is the size of the prize (payoff difference) generated in the asymmetric equilibrium, corresponding to the terms in the curly brackets {}. The first term in the curly brackets, $\alpha Q[2\lambda-1]\cdot[\bar{K}+(1+t)h_s]$ is the difference in the revenue evaluated at h_s, resulting from a part of the first period capital accumulation, based upon the difference in the rank-order in the first period competition. $(2\lambda-1)$ represents the difference in the assigned allotments. Due to this, the winner can gain more revenue, even with equal equilibrium incentives. The second term $\bar{v}-\underline{v}$ represents the payoff difference in the second period between the winner and the loser. Of course, the marginal strategic effect $(1-t)\phi(e_W^*-e_L^*)W$ is positive for $0<t<1$. On the other hand, the RHS is the direct effect (33), which implies that the competition has a negative incentive effect from this point of view. Here we can recognize the following facts. First, as $f(0)$ is larger, that is, as the support of uncertainty at the end of the first period becomes smaller, this inequality tends to be satisfied. [26] In addition, as the discrete prize is larger in equilibrium, investment over the hold-up level defined by (34) tends to be induced. [27] Nonetheless, note that whether the principal really has an incentive to induce the above incentive is another problem.

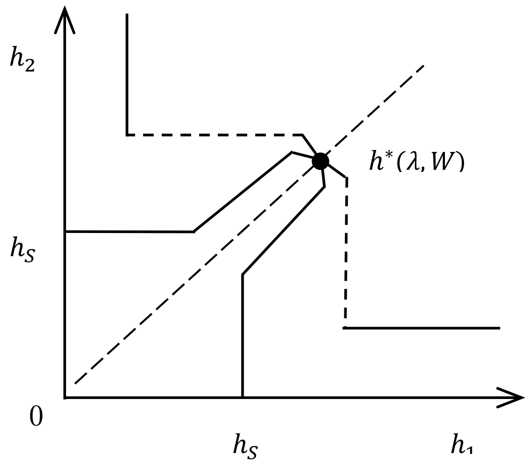

Figure 4 Equilibrium Investment Level $h^*(\lambda, W)$ in the First Period.

3.3 Feasibility of First-Best Solutions in Dynamic Tournaments between Homogeneous Agents

Homogeneous agents refer to the case of the two agents having the same α $(\boldsymbol{\alpha_1=\alpha_2=\alpha, 0\le\alpha\le1})$ in the

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[26] Although political systems differ depending on whether they are dictatorships or democracies, the Chinese Communist Party regime and the long-term government of the Liberal Democratic Party in Japan in the catch-up era have in common the fact that political uncertainty is small. In other words, f(0) is large.

[27] This (first-period) prize is a quasi-rent created by the government, and the fact that China has been providing large subsidies for R&D and innovation achievements in recent years is equivalent to the situation where W is large. This is a mechanism for arousing competition among rival companies to win this quasi-rent and create quality improvement and innovation. Although the Chinese government has recently become more centralized, such incentive devices themselves by the government share an essential function with Aoki et al (1996)'s "market enhancement view".

competition between SOEs $\mathbf{0 \leq \alpha < 1/2}$ and between POEs $\mathbf{1/2 < \alpha \leq 1}$.

The solution of equations (13) and (14) represents a Nash equilibrium in the second period.

$$\alpha \cdot \lambda \cdot Q + \phi(\Delta K + e_w - e_L) \cdot W - C'(e_W) = 0. \quad (13)$$

$$\alpha \cdot (1-\lambda) \cdot Q + \phi(\Delta K + e_w - e_L) \cdot W - C'(e_L) = 0. \quad (14)$$

The FOC that characterizes the level of investment h^* in the first period symmetric equilibrium is

$$\delta \cdot \{\alpha(1-\lambda) \cdot Q \cdot 1 + F(0) \cdot [(2\lambda - 1) \cdot \alpha Q + 2(1-t)\phi(e_W^* - e_L^*)W]$$
$$+[(2\lambda-1)\alpha Q(\bar{K} + (1+t) \cdot h^*) + \bar{v} - \underline{v}] \cdot f(0)\} = g'(h^*). \quad (28)$$

$$\delta \cdot \{{}^1\!/_2\, \alpha \cdot Q + (1-t)\phi(e_W^* - e_L^*)W + \left[(2\lambda-1)\alpha Q(\bar{K} + (1+t)h^*) + \bar{v} - \underline{v}\right] f(0)\} = g'(h^*). \quad (28')$$

This is compared with the following FOCs, which characterize the optimal investment levels e^{FB} and h^{FB} **under the complete contract**.

$$Q = C'(e^{FB}). \quad (3)$$

$$\delta Q = g'(h^{FB}). \quad (4)$$

Comparing (13) (14) and (3), we see that the first term shows that the "hold-up effect" appearing in $\alpha \leqq 1$ is further deteriorated by dividing into λ and $1-\lambda$, but the second term $\phi \cdot W$ is the tournament effect, which induces incentives for the second period. If the sum of the two terms reaches Q on the LHS of (3), the first-best level can be achieved. Under this, comparing the LHSs of (28') and (4) and eliminating the common denominator δ, we can see that the first best investment level h^{FB} can be achieved in the equilibrium h^* of the first period, if ${}^1\!/_2\, \alpha \cdot Q + \left[(2\lambda - 1)\alpha Q(\bar{K} + (1+t)h^*) + \bar{v} - \underline{v}\right] f(0) = Q$.

In other words, the first term ${}^1\!/_2\, \alpha \cdot Q$ means that the "hold-up effect" α is exacerbated by the probability of winning ${}^1\!/_2$, but if the total effects of the marginal strategic effect of the second term and the tournament prize of winning the first period competition of the third term $\left[(2\lambda-1)\alpha Q(\bar{K} + (1+t)h^*) + \bar{v} - \underline{v}\right] f(0)$ reaches Q, the first best investment level h^{FB} in the first period could also be achieved at equilibrium. The condition is that

$$(1-t)\phi(e_W^* - e_L^*)W + \left[(2\lambda-1)\alpha Q(\bar{K} + (1+t)h^*) + \bar{v} - \underline{v}\right] f(0) = \left(1 - {}^1\!/_2\, \alpha\right)Q. \quad (35)$$

We can see that the right side is **more severe (tighter)** than the condition when the investment level in the first period exceeds the hold-up level h^S. Using this as a benchmark, we will compare the conditions for the first best feasibility in the tournament between heterogeneous agents.

3.4 On the Government (Principal)'s Strategies

We focus here on the behavior of the principal. This is theoretically the problem concerning the optimal contract design for her to maximize her private profit. At the beginning of the first period, the principal then chooses both λ (the production share assigned to the first period winner) and W (the monetary prize given to the final winner), and commits to the two strategies. The principal's payoff function[28] (as her objective) is,

$$\delta \cdot (1-\alpha) \cdot Q \cdot 2 \cdot \{(\bar{K} + (1+t)h^*) + [\lambda \cdot e_W^* + (1-\lambda) \cdot e_L^*]\} - W. \quad (36)$$

This formula implies the principal's share of the total value generated by the induced incentives, minus her fixed cost

[28] The expected payoff that she can obtain at equilibrium of the continuation game played by the two agents, given her strategies $\{\lambda, W\}$.

(monetary prize). That is, the principal's problem is to maximize the expected payoff $\pi(\lambda, W)$ defined as a function of both λ and W, subject to the inequality constraints $1/2 \le \lambda \le 1$ and $W \ge 0$, the global incentive constraints of the agents in the first and second periods, the solution thus becoming the second-best mechanism. See Suzuki (2003) for an attempt to fully characterize this problem. This paper focuses on **comparing homogeneous and heterogeneous tournaments**, assuming the inner solutions, and deriving **implications for institutional design and reform** from the theoretical analysis.[29]

4. Heterogeneous Tournaments with different bargaining powers (ownership ratios)

From this section, we remove the assumption that the ownership ratio of the company (the bargaining power reflecting it, which is the assumption of homogeneous tournaments) is equal $\alpha_1 = \alpha_2 = \alpha$, and analyze **the tournament competition between heterogeneous players**. We focus on the **heterogeneous tournament between a POE α_P and an SOE α_S** $0 \le \alpha_S < \frac{1}{2} \le \alpha_P \le 1$, which implies the heterogeneous competition under incomplete contracting situations suggested by Hart, Shleifer, and Vishney (1997).

4.1. <u>Case1: Common Prize *W*</u>

4.1.1. Second Period Equilibrium

The FOCs in the competition between heterogeneous agents (a POE and an SOE) in the second period are

$$\alpha_P \cdot \lambda \cdot Q + \frac{\partial \Phi(\Delta K + e_w - e_L)}{\partial e_W} \cdot W - C'(e_W) = 0. \qquad (11')$$

$$\alpha_S \cdot (1-\lambda) \cdot Q - \frac{\partial \Phi(\Delta K + e_w - e_L)}{\partial e_L} \cdot W - C'(e_L) = 0. \qquad (12')$$

In other words, the solution of the following simultaneous equations (13') and (14') represents the Nash equilibrium of the second stage.

$$\alpha_P \cdot \lambda \cdot Q + \phi(\Delta K + e_w - e_L) \cdot W - C'(e_W) = 0. \qquad (13')$$

$$\alpha_S \cdot (1-\lambda) \cdot Q + \phi(\Delta K + e_w - e_L) \cdot W - C'(e_L) = 0. \qquad (14')$$

We assume that the SOCs are satisfied.

[Proposition 7].

In the investment competition in the second stage, the amount of investment by the winner α_P of the previous period is strictly larger than that by the loser α_S.

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[29] There would be some justification for assuming the inner solution $\lambda^* \in (1/2, 1), W^* > 0$. From the viewpoint of institutional dynamics, that the government (principal) could optimally determine the solution on (λ, W) in every period would not be natural, but rather the institution (consisting of government and firms) would change more gradually. From the viewpoint of behavioral economics, the "status-quo bias" would prevent the government from adjusting the optimal solution in every period. In the Chinese mixed ownership system, the state-owned enterprise and the private enterprise compete with each other, and the elimination of the loser from the competition (market) would not occur very often.

[Proof]

To compare the incentives of both agents, taking the difference between the equations $(13')$ and $(14')$, due to the Common Prize we obtain

$$C'(e_w) - C'(e_L) = \alpha_P \cdot \lambda \cdot Q - \alpha_S \cdot (1-\lambda) \cdot Q = \underbrace{(\alpha_P - \alpha_S) \cdot \lambda \cdot Q} + \underbrace{(2\lambda - 1) \cdot \alpha_S \cdot Q} > 0. \qquad (15')$$

Since $0 \le \alpha_S < \frac{1}{2} \le \alpha_P \le 1,\ Q > 0,\ \lambda > \frac{1}{2}$ and C' is increasing in e, we obtain the result.

$$e_W^* > e_L^* \Leftrightarrow e_P^W > e_S^L. \qquad (16')$$

Q.E.D.

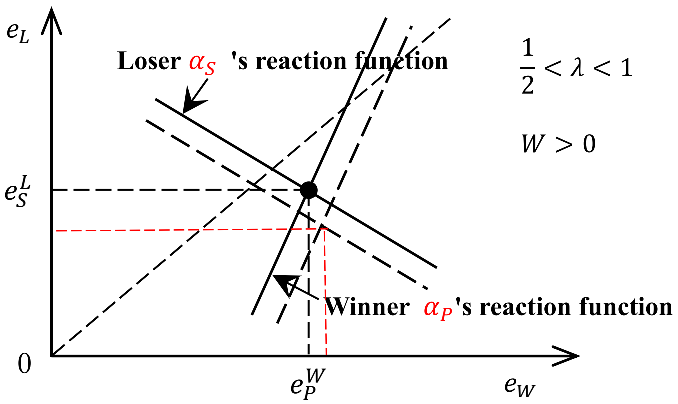

Figure 5.1:Equilibrium in the Second Period when α_P winner and α_S loser in the First Period.

The expected profits that the winner α_P and the loser α_S of the first period obtain in the asymmetric equilibrium of the second period are as follows.

$$V_{2W}^P = \alpha_P \cdot \lambda \cdot Q\left(K_{\alpha_P 2} + e_P^W\right) + \Phi^{\alpha_P} \cdot W - C(e_P^W), \qquad (20')$$

$$V_{2L}^S = \alpha_S \cdot (1-\lambda) \cdot Q\left(K_{\alpha_S 2} + e_S^L\right) + (1 - \Phi^{\alpha_P}) \cdot W - C(e_S^L), \qquad (21')$$

where $\Phi(\Delta K + e_P^W - e_S^L) > \frac{1}{2}, K_{i2} = \bar{K} + (h_i + \varepsilon_i) + t\left(h_j + \varepsilon_j\right), i = \alpha_P, \alpha_S, i \neq j.$

Similarly, the FOCs on the competition of the second period in the case of the first period winner α_S and the loser α_P (SOE winner α_S, POE loser α_P) are

$$\alpha_P \cdot (1-\lambda) \cdot Q - \frac{\partial \Phi(\Delta K + e_w - e_L)}{\partial e_L} \cdot W - C'(e_L) = 0. \qquad (11'')$$

$$\alpha_S \cdot \lambda \cdot Q + \frac{\partial \Phi(\Delta K + e_w - e_L)}{\partial e_W} \cdot W - C'(e_W) = 0. \qquad (12'')$$

In other words, the solution of the simultaneous equation of the following equations (13')(14') represents the Nash equilibrium of the second period.

$$\alpha_P \cdot (1-\lambda) \cdot Q + \phi(\Delta K + e_w - e_L) \cdot W - C'(e_L) = 0. \qquad (13'')$$

$$\alpha_S \cdot \lambda \cdot Q + \phi(\Delta K + e_w - e_L) \cdot W - C'(e_w) = 0. \qquad (14'')$$

Assume that the SOCs are satisfied.

[Proposition 8].

In the second period of the investment competition, the necessary and sufficient condition for the winner α_S *in the* *previous period to exceed the amount of investment of the loser* α_P *is* $\alpha_S \cdot \lambda > \alpha_P \cdot (1-\lambda) \Leftrightarrow \frac{\lambda}{(1-\lambda)} > \frac{\alpha_P}{\alpha_S}$.

[Proof]

To compare the incentives of both agents, we take the difference between equations (13'') and (14'')

$$C'(e_W) - C'(e_L) = \alpha_S \cdot \lambda - \alpha_P \cdot (1-\lambda). \tag{15''}$$

Since C' is increasing in e, we obtain the condition

$$e_W^* > e_L^* \Leftrightarrow \alpha_S \cdot \lambda > \alpha_P \cdot (1-\lambda). \tag{16''}$$

We now assume that $\frac{\lambda}{1-\lambda} > \frac{\alpha_P}{\alpha_S} > 1$, that is, the case in which **the difference in quantity assignment** to the winner in the previous period is ***more effective*** than **the difference in bargaining powers (ownership ratios)**. This allows us to assume that even if bargaining power (ownership ratio) is *unfavorable* ($\alpha_S < \alpha_P$), the company will have *an incentive to try its best to reverse the situation* in the first period.

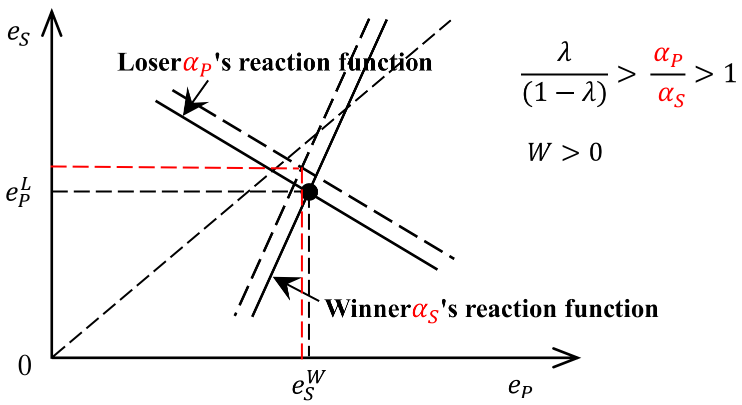

Figure 5. 2: Equilibrium in the Second Period when α_S winner and α_P loser in the First Period.

The expected profits that the winner α_S and the loser α_P of the first period obtain **in the asymmetric equilibrium of the second period** are as follows.

$$V_{2W}^S = \alpha_S \cdot \lambda \cdot Q\left(K_{\alpha_S 2} + e_S^W\right) + \Phi^{\alpha_S} \cdot W - C(e_S^W), \tag{20'}$$

$$V_{2L}^P = \alpha_P \cdot (1-\lambda) \cdot Q\left(K_{\alpha_P 2} + e_P^L\right) + (1-\Phi^{\alpha_S}) \cdot W - C(e_P^L), \tag{21'}$$

where $\Phi^{\alpha_S} = \Phi(\Delta K + e_S^W - e_P^L) > \frac{1}{2}$ and $K_{i2} = \overline{K} + (h_i + \varepsilon_i) + t\left(h_j + \varepsilon_j\right)$, $i = \alpha_P, \alpha_S, i \neq j$.

In **a heterogeneous tournament, the difference in equilibrium profit (the prize) is different for both**.

The prize for POE α_P is

$$\Delta V_{\alpha_P}\left(\alpha_P Q, K_{\alpha_P 2}, \lambda, W\right)$$
$$= \alpha_P \cdot (\mathbf{2\lambda - 1}) \cdot Q \cdot K_{\alpha_P 2} + \{\alpha_P \boldsymbol{Q} \cdot [\lambda\, e_P^W - (1-\lambda) e_P^L] + (\Phi^{\alpha_P} + \Phi^{\alpha_S} - 1) \cdot W - [C(e_P^W) - C(e_P^L)]\}.$$

The prize for SOE α_S is

$$\Delta V_{\alpha_S}\left(\alpha_S Q, K_{\alpha_S 2}, \lambda, W\right)$$
$$= \alpha_S \cdot (\mathbf{2\lambda - 1}) \cdot Q \cdot K_{\alpha_S 2} + \{\alpha_S \boldsymbol{Q} \cdot [\lambda\, e_S^W - (1-\lambda) e_S^L] + (\Phi^{\alpha_P} + \Phi^{\alpha_S} - 1) \cdot W - [C(e_S^W) - C(e_S^L)]\}.$$

We thus confirm that **the discrete prizes** that increase the incentives of the heterogeneous agents α_P, α_S in the first period are **different between the two**.

4.1.2. First-Period Equilibrium in the Heterogeneous Tournament (α_P, α_S).

The capital stock of the agent α_P at the end of the first period is

$$\widetilde{K}_{\alpha_P 1} = \overline{K} + h_{\alpha_P} + \varepsilon_{\alpha_P}. \qquad (23')$$

$\overline{K}$ is the capital stock at the beginning of the period, h_P is the investment level of POE α_P, and ε_P is the uncertainty factor. Supposing that $F(h)$ is the probability that the POE α_P wins the competition in the first period,

$$F = Prob(\widetilde{K}_{\alpha_P 1} > \widetilde{K}_{\alpha_S 1}) = Prob(h_{\alpha_P} - h_{\alpha_S} > \varepsilon_{\alpha_S} - \varepsilon_{\alpha_P}) = F(h_{\alpha_P} - h_{\alpha_S}) \qquad (24')$$

where $\varepsilon_{\alpha_S} - \varepsilon_{\alpha_P}$ is the relative noise of the first period, and F is a distribution function of the random variable $\varepsilon_{\alpha_S} - \varepsilon_{\alpha_P}$.

The agent (POE) α_P faces the following tournament scheme in the first period.

$$S^{\alpha_P}(\widetilde{K}_{\alpha_P 1}, \widetilde{K}_{\alpha_S 1}) = \begin{cases} V_{2L}^{\alpha_P} & \text{if } \widetilde{K}_{\alpha_P 1} < \widetilde{K}_{\alpha_S 1} \\ V_{2L}^{\alpha_P} + \Delta V_{\alpha_P} & \text{if } \widetilde{K}_{\alpha_P 1} > \widetilde{K}_{\alpha_S 1} \end{cases}$$

In other words, if the agent (POE) α_P is **ranked first** in the competition between a POE α_P and an SOE α_S, he can obtain **a discrete prize** $\boldsymbol{\Delta V_{\alpha_P}}$ in addition to $V_{2L}^{\alpha_P}$. (Figure 6.1).

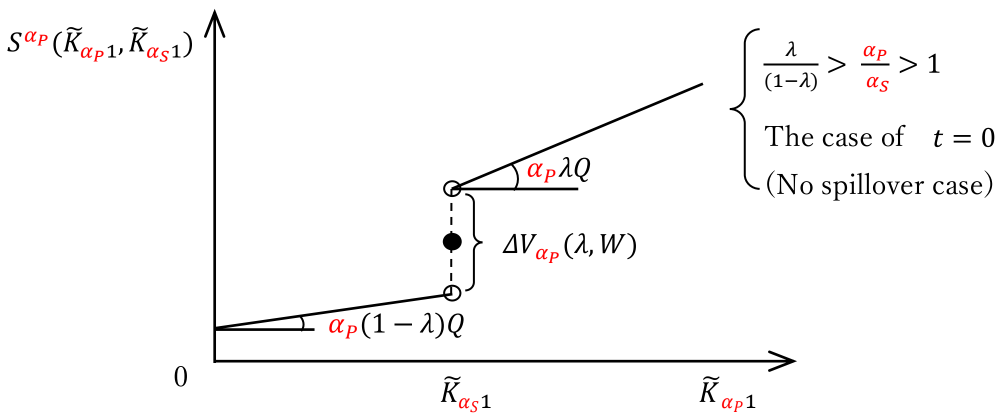

Figure 6.1 Tournament Scheme Facing **Agent** α_P in the First period.

Similarly, the agent (SOE) α_S is facing the following tournament scheme in the first period.

$$S^{\alpha_S}(\widetilde{K}_{\alpha_S 1}, \widetilde{K}_{\alpha_P 1}) = \begin{cases} V_{2L}^{\alpha_S} & \text{if} \widetilde{K}_{\alpha_S 1} < \widetilde{K}_{\alpha_P 1} \\ V_{2L}^{\alpha_S} + \Delta V_{\alpha_S} & \text{if } \widetilde{K}_{\alpha_S 1} > \widetilde{K}_{\alpha_P 1} \end{cases}$$

If the agent (SOE) α_S is **ranked first** in the competition between α_P and α_S, he can obtain **a discrete prize** $\boldsymbol{\Delta V_{\alpha_S}}$ in addition to $V_{2L}^{\alpha_S}$. (Figure 6.2).

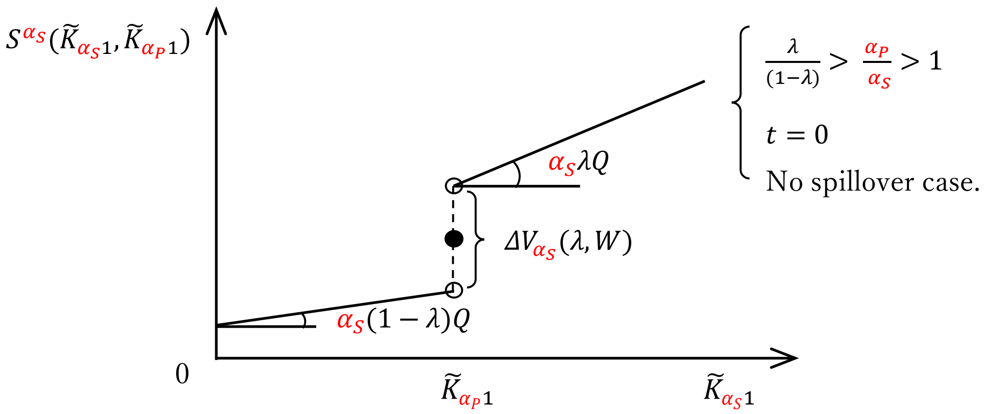

Figure 6.2 Tournament Scheme Facing **Agent** α_S in the First Period.

As described above, each of the two **"heterogeneous agents"** faces a **"different tournament scheme"** in the first period, predicts the opponent's behavior, and solves the following problem simultaneously and independently.

$$\max_{h_i} \delta \cdot \mathop{E}_{\varepsilon}\{F(h) \cdot V_{2W}^i + (1 - F(h)) \cdot V_{2L}^i\} - g(h_i) \qquad i = \alpha_P, \alpha_S. \tag{25'}$$

The Fundamental Equation of this problem is

$$V_i(\alpha_P, \alpha_S) = \max_{h_i} \delta \cdot \{V_{2L}^i + F(h) \cdot \Delta V_i\} - g(h_i) \qquad i = \alpha_P, \alpha_S. \tag{26'}$$

The FOC for the agent α_P is:

$$\delta \cdot \{\alpha_P(1-\lambda)Q \cdot 1 + F(h_{\alpha_P} - h_{\alpha_S}) \cdot [(2\lambda - 1)\alpha_P Q \cdot 1 + 2(1-t)\phi(\Delta K + e_P^W - e_S^L)W]$$
$$+ [(2\lambda - 1)\alpha_P Q K_{\alpha_P 2} + \bar{\upsilon}_P - \underline{\upsilon}_P] f(h_{\alpha_P} - h_{\alpha_S})\} - g'(h_{\alpha_P}) = 0. \tag{27'}$$

where $K_{\alpha_P 2} = \bar{K} + (h_{\alpha_P} + \varepsilon_{\alpha_P}) + t \cdot (h_{\alpha_S} + \varepsilon_{\alpha_S})$ is a function which represents the notion that when the agent α_P reaches the accumulation of $\tilde{K}_{\alpha_P 1}$ in the capital accumulation competition in the first period, it arrives at the modified asset $K_{\alpha_P 2}$ through the process of the technology transfer from $\tilde{K}_{\alpha_S 1}$.[30]

In addition, $\bar{\upsilon}_P$ and $\underline{\upsilon}_P$ are defined as follows.

$$\bar{\upsilon}_P = \bar{\upsilon}(\alpha_P, Q, \lambda, W) = \alpha_P \lambda Q e_P^W + \Phi^{\alpha_P} \cdot W - C(e_P^W),$$
$$\underline{\upsilon}_P = \underline{\upsilon}(\alpha_P, Q, (1-\lambda), W) = \alpha_P(1-\lambda)Q e_P^L + (1 - \Phi^{\alpha_S}) \cdot W - C(e_P^L),$$

where $\Phi^{\alpha_P} = \Phi(\Delta K + e_P^W - e_S^L) > 1/2$, and $\Phi^{\alpha_S} = \Phi(\Delta K + e_S^W - e_P^L) > 1/2$.

The FOC in the first period is arranged as follows.

$$\delta \cdot \{\alpha_P(1-\lambda) \cdot Q \cdot 1 + F(h_{\alpha_P} - h_{\alpha_S}) \cdot [(2\lambda - 1) \cdot \alpha_P Q + 2(1-t)\phi(\Delta K + e_P^W - e_S^L)W]$$
$$+ [(2\lambda - 1)\alpha_P Q(\bar{K} + h_{\alpha_P} + t h_{\alpha_S}) + \bar{\upsilon}_P - \underline{\upsilon}_P] \cdot f(h_{\alpha_P} - h_{\alpha_S})\} = g'(h_{\alpha_P}). \tag{28'}$$

A similar condition can also be obtained for the agent α_S.

$$\delta \cdot \{\alpha_S(1-\lambda) \cdot Q \cdot 1 + \left(1 - F(h_{\alpha_P} - h_{\alpha_S})\right) \cdot [(2\lambda - 1) \cdot \alpha_S Q + 2(1-t)\phi(\Delta K + e_S^W - e_P^L)W]$$
$$+ [(2\lambda - 1)\alpha_S Q(\bar{K} + h_{\alpha_S} + t h_{\alpha_P}) + \bar{\upsilon}_S - \underline{\upsilon}_S] \cdot f(h_{\alpha_P} - h_{\alpha_S})\} = g'(h_{\alpha_S}). \tag{28"}$$

Although the solution of these simultaneous equations will characterize the investment levels on the equilibrium

[30] Recall (23), (23') and the assumption of linear transfer technology (Assumption 1). Also refer to footnote 15.

path in the first period, it should be noted that both agents are ***heterogeneous players***, since they differ in the bargaining power reflecting the ownership structure. Thus, we **cannot impose the symmetry condition at equilibrium** $h_{\alpha_P} = h_{\alpha_S} = h^*$.

The three terms in the LHS of (28') or (28'') represent the following effects. The first term represents the marginal increase in the value $V_{2L}^i, i = \alpha_P, \alpha_S$ ((21)) that is expected to be obtained at the second period Nash equilibrium, when he loses in the first period competition, through the increase in capital investment in the first period. The second term represents the marginal increase in the discrete prize: $V_{2W}^i - V_{2L}^i, i = \alpha_P, \alpha_S$ itself, with the probability of winning being $F(h_{\alpha_P} - h_{\alpha_S}) > \frac{1}{2}$, $1 - F(h_{\alpha_P} - h_{\alpha_S}) < \frac{1}{2}$ at equilibrium. The two terms in the brackets of the second term are, respectively, ***the direct effect*** and ***the marginal strategic effect***. The direct effect means the marginal revenue from the increase in the assigned quantity $(2\lambda - 1)$, with winning probability at equilibrium. ***The marginal strategic effect*** $F(h_{\alpha_P} - h_{\alpha_S}) \times 2(1-t)\phi(\Delta K + e_P^W - e_S^L)W$ implies a strategic incentive for the agent α_P to increase marginally the probability of winning in the final period through increasing the difference in the first period capital accumulation. The third term is ***the tournament effect*** through marginal improvement $f(h_{\alpha_P} - h_{\alpha_S})(< f(0))$ in the probability of winning, given the equilibrium payoff difference, that is, the discrete prize.

Let us now compare **the first period asymmetric equilibrium case** with **the symmetric equilibrium case** to see whether the level of investment in the asymmetric equilibrium is likely to achieve the first-best level of investment or the conditions above the hold-up level. The POE with greater bargaining power (ownership ratio) α_P has a probability greater than one-half of winning at equilibrium, but the probability density at equilibrium is less than at the time of symmetric equilibrium. Therefore, it is not possible to make a generalization. On the other hand, the SOE with small bargaining power (ownership ratio) α_S has a less than half chance of winning at equilibrium, and the probability density at equilibrium is also reduced from that of symmetric equilibrium. Furthermore, marginal strategic effects fall because the probability density at equilibrium decreases as the difference ΔK between the two agents is larger. In addition, if the **feedback effect** between the investments of both companies [31]is strong, the first period investments $h_{\alpha_P} + th_{\alpha_S}$, $h_{\alpha_S} + th_{\alpha_P}$ may fall for both, leading to a fall in the size of the prize itself. Therefore, the sum of the direct effect, strategic effect, and tournament effect on the left side will always fall, making it difficult to achieve the first-best level and reducing FB Implementability. This can be said to be **a problem with asymmetrical tournaments**.

[Proposition 9].

In the heterogeneous tournaments with a common prize $\boldsymbol{W}$ between the POE $\boldsymbol{\alpha_P}$ and the SOE $\boldsymbol{\alpha_S}$, each of whom faces a different tournament scheme, the POE with greater bargaining power (ownership ratio) $\boldsymbol{\alpha_P > \alpha_S}$ will win the tournaments. However, at the asymmetric equilibrium in the first period, the increase in the winner $\boldsymbol{\alpha_P}$'s investment may greatly reduce the loser$\boldsymbol{\alpha_S}$'s investment, which in turn may greatly reduce the winner's investment,

[31] e_W and $e_L$are **strategic complements for the winner**, and e_L and e_W are **strategic substitutes for the loser**. This also applies to the relation in h_1 and h_2. Consequently, the increase in the winner's investment (becoming aggressive) may greatly reduce the loser's investment (making it passive),which may greatly reduce the winner's investment due to **the feedback effect**. Since the loser (2nd place) is demotivated, the winner (1st place) is also relieved and weakens (cuts corners on) his investment.

due to the feedback effect. This decline in equilibrium incentives could be a serious problem.

4.1.3. When $\frac{\lambda}{(1-\lambda)} < \frac{\alpha_P}{\alpha_S} \Leftrightarrow \alpha_P(1-\lambda) > \alpha_S\lambda$ holds, where **the difference in bargaining powers (ownership ratios)** is ***more effective*** than **the difference in quantity assignment**.

In the competition between the POEα_P and the SOEα_S, the difference in bargaining power (ownership ratio), $\alpha_P - \alpha_S$, can be greater than $1/2$. That is, the "**degree of heterogeneity"** in heterogeneous tournaments is large.

Then, even in the case of the winner, which is the SOE α_S, and the loser, which is the POE α_P in the first period, the relation $\alpha_S \cdot \lambda < \alpha_P \cdot (1-\lambda)$is likely to be established. At this time, even if the SOE α_S wins in the first period, at the equilibrium of the second period the POE α_P invests more as shown in the figure below, and will become the winner.

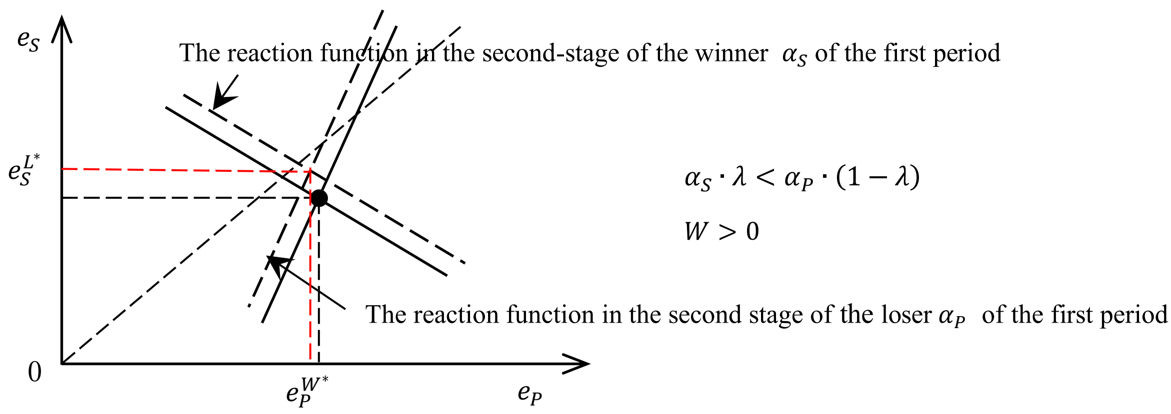

Figure 7.1 POE (the loser α_P of the first period) invests more at the second term equilibrium.

The expected profits that the winner and the loser (<u>the winner: the SOE α_S</u>, <u>the loser: the POE α_P</u>) of the first period obtain at the asymmetric equilibrium of the second period are as follows.

$$V_{2P}^{*} = \alpha_P \cdot (1-\lambda) \cdot Q\left(K_{\alpha_P 2} + \ e_P^{W^*}\right) + \Phi^* \cdot W - C\left(e_P^{W^*}\right). \qquad (20")$$

$$V_{2S}^{*} = \alpha_S \cdot \lambda \cdot Q\left(K_{\alpha_S 2} + e_S^{L^*}\right) + (1-\Phi^*) \cdot W - C\left(e_S^{L^*}\right). \qquad (21")$$

Conversely, in the case of the winner, which is a POE α_P, and the loser, which is an SOE α_S, it is likely that the private enterprise $\alpha_P$will **always invest more and win again** at the asymmetric equilibrium in the second period. The expected profits obtained in the equilibrium of the second period are as follows.

$$V_{2W}^{P} = \alpha_P \cdot \lambda \cdot Q\left(K_{\alpha_P 2} + e_P^{W}\right) + \Phi \cdot W - C(e_P^{W}). \qquad (20''')$$

$$V_{2L}^{S} = \alpha_S \cdot (1-\lambda) \cdot Q\left(K_{\alpha_S 2} + e_S^{L}\right) + (1-\Phi) \cdot W - C(e_S^{L}). \qquad (21''')$$

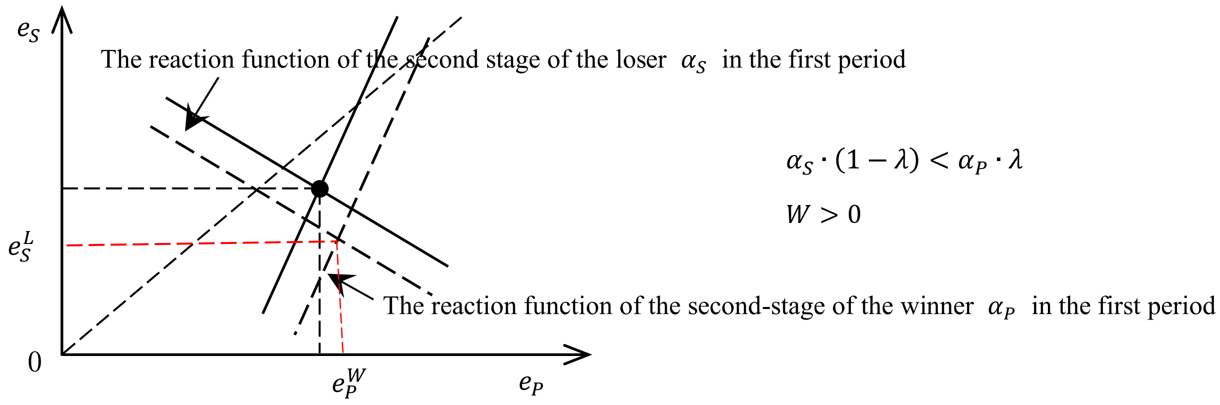

Figure 7.2 POE (the winner α_P of the first period) invests more and win again at the second term equilibrium.

The difference in equilibrium profits (prize) differs for both parties in the heterogenous tournaments.
For the POE α_P, it is
$\Delta V^*(\alpha_P Q, K_{\alpha_P 2}, \lambda, W) = \alpha_P \cdot (2\lambda - 1) \cdot Q \cdot K_{\alpha_P 2} + \{\alpha_P Q \cdot [\lambda e_P^W - (1-\lambda) e_P^{W^*}] + (\Phi - \Phi^*) \cdot W - [C(e_P^W) - C(e_P^{W^*})]\}$.
For the SOE α_S, it is
$\Delta V^*(\alpha_S Q, K_{\alpha_S 2}, \lambda, W) = \alpha_S \cdot (2\lambda - 1) \cdot Q \cdot K_{\alpha_S 2} + \{\alpha_S Q \cdot [\lambda e_S^{L^*} - (1-\lambda) e_S^L] + (\Phi - \Phi^*) \cdot W - [C(e_S^{L^*}) - C(e_S^L)]\}$.
That the size of the discrete prize, which enhances the first period incentives of the two heterogeneous agents α_S, α_P, is different for both is the same as noted previously. However, **the "possibility of reversal"** will also be large. Whether the SOE α_S wins or loses in the first period, it is likely to lose in the second period, while the POE α_P is likely to win in the second period, regardless of whether it wins or loses in the first period.

Thus, **the size of the discrete prize becomes smaller** for both, which makes it difficult to induce investment incentives in the first period. This corresponds to **a decrease in competitive pressure** (i.e., a decrease in the motivational function) when the heterogeneous agents have **more than a certain difference in $\alpha_P - \alpha_S$.**

[Corollary 3].
In the heterogeneous tournaments with a common prize W, where the difference in bargaining powers (ownership ratios) is *more effective* than the difference in quantity assignment, the POE α_P will win and the SOE α_S will lose in the second period, regardless of whether they won or lost in the first period. Thus, the size of the discrete prize becomes smaller for both, which makes it difficult to induce incentives in the first period. This will bring about a decrease in competitive pressure.

4.2 Case 2: Different Prizes for the POE α_P and the SOE α_S

In this section, **we change the setting** of the common monetary reward W thus far, and consider a case in which the SOE receives a greater monetary (nonmonetary) reward for winning the competition than the POE. In other words, the POE does not receive as much reward for winning the competition as the manager of the SOE. This can be said to be an institutional situation in which the manager of the SOE has a clear path to promotion to a high position in the government and other ancillary benefits by winning the competition, while the manager of the POE does not have these benefits. In short, this is a situation where **the prizes for the two enterprises are different**, and to represent the difference, let us assume that **the discounted prize** of the POE is $\boldsymbol{\theta \cdot W}, 0 \leq \theta \leq 1$[32] .

In the case where the POE α_P is the winner and the SOE α_S is the loser of the first period, the POE α_P is assigned λ and the SOE α_S is assigned $1-\lambda$ at the beginning of the second period. The FOCs for the competition between the heterogeneous agents in the second period then become as follows.

$$\alpha_P \cdot \lambda \cdot Q + \frac{\partial \Phi(\Delta K + e_w - e_L)}{\partial e_W} \cdot \theta \cdot W - C'(e_W) = 0. \tag{11D}$$

$$\alpha_S \cdot (1-\lambda) \cdot Q - \frac{\partial \Phi(\Delta K + e_w - e_L)}{\partial e_L} \cdot W - C'(e_L) = 0. \tag{12D}$$

In other words, the solution of the simultaneous equations of the following (13D) and (14D) represents the Nash equilibrium of the second period.

$$\alpha_P \cdot \lambda \cdot Q + \phi(\Delta K + e_w - e_L) \cdot \theta \cdot W - C'(e_W) = 0. \tag{13D}$$
$$\alpha_S \cdot (1-\lambda) \cdot Q + \phi(\Delta K + e_w - e_L) \cdot W - C'(e_L) = 0. \tag{14D}$$

The threshold $\boldsymbol{\theta^*}$ for the POE α_P to make larger investments in the second period equilibrium is then determined by **the equality**:

$$\alpha_P \cdot \lambda \cdot Q + \phi(\Delta K) \cdot \theta \cdot W = \alpha_S \cdot (1-\lambda) \cdot Q + \phi(\Delta K) \cdot W. \tag{37}$$

We have the threshold as $\theta^* = 1 - \frac{(\alpha_P \cdot \lambda - \alpha_S \cdot (1-\lambda))Q}{\phi(\Delta K) \cdot W}$. When $\theta > \theta^*$, the POE α_P can invest more at the second period equilibrium, and the analysis of heterogeneous tournaments in section 4.1 can be almost applied. When $\theta < \theta^*$, the SOE α_S always invests more (the winner), and the POE α_P always invests less (the loser) at the second period equilibrium, which brings about the adverse effect due to the "Cronyism", as explained later.

When $\boldsymbol{\theta > \theta^*}$.That the POE α_P or the SOE α_S that won in the first period will invest more in the second period, and the POE α_P or the SOE $\alpha_S$that lost in the first period will invest less in the second period is the same as in the previous analysis on the heterogeneous tournaments. Nonetheless, since the monetary reward *W* for the POE α_P is discounted by $\theta \leq 1$, the level of investment e_P^W at equilibrium will be lowered, and the investment level e_S^L of the loser (the SOE), which is in a *strategic substitute* relationship with e_P^W, will become higher, when the POE α_P is the winner and the SOE α_S is the loser in the first period. On the other hand, when the SOE α_S is the winner and the POE α_P is the loser in the first period, the investment level e_P^L of the loser (POE) at equilibrium will be lowered, and the level of investment e_S^W of the winner (SOE), which is in a *strategic complement* relationship with e_P^L, will also become lower. Since the prize for the POE α_P for winning the first period competition will become smaller, the level of investment h_{α_P} of the POE at the asymmetric equilibrium of the first period will be lower, the level of investment h_{α_S} of the SOE in the *strategic substitute* relationship will be higher, and thus the difference in investments between the two companies will narrow. This would be the same as **the effect of handicapping more lucrative companies** α_P (or **giving subsidies in favor of SOEs** α_S).[33]

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[32] This situation could be implemented by institutional design of the state leader (government).

[33] These represent **the handicapping for the winner** α_P and **favoritism for the loser** α_S. If designed properly, they

When $\boldsymbol{\theta < \theta^*}$.The SOE α_S, in the event of losing in the first period, is assigned $1-\lambda$ to invest more (that is, **reverse the position** of the POE) in the second period equilibrium, as the Fig. 8 shows.

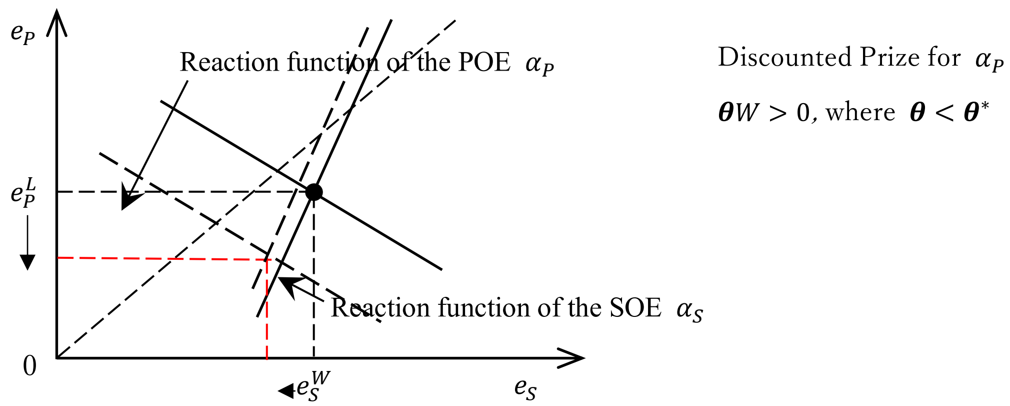

Fig. 8. The case of $\boldsymbol{\theta < \theta^*}$: Adverse Effect of "Cronyism": Decline of Competitive Pressure.

If the SOE $\alpha_S$wins in the first period and is allocated λ in the second period, it will invest more at the asymmetric equilibrium in the second period (the level of investment itself will also be higher.) The POE α_P is assigned $1-\lambda$ to invest less (the level of investment itself is also lower).

In summary, when $\theta < \theta^*$, as for the SOE α_S and the POE α_P, there is a large possibility of reversal in the second period by the SOE, and the SOE is likely to win the second period, even if it wins or loses in the first period. While on the other hand, the POE α_P is likely to lose in the second period, even if it wins or loses in the first period. Therefore, the sizes of the discrete prizes expected in the first period are smaller for both types of enterprises. Thus, the investment incentive in the first period will be even less attractive. In the previous section, it was shown that when the difference $\boldsymbol{\alpha_P - \alpha_S}$ between the heterogeneous agents exceeds a certain level, competitive pressure will fall. In this section, however, the POE loses its initial favorable bargaining power (ownership ratio) $\alpha_P - \alpha_S > 0$ because the subsidy (prize) W is discounted by the government in the form of $\theta \cdot W, \theta \in [0,1]$. If the degree is excessively large $\theta < \theta^*$, the POE only invests in anticipation of the smaller allotment in the form of $1-\lambda$. In other words, due to the unfair competitive environment, only investment levels equivalent to hold-up $\alpha_P(1-\lambda)Q = g'(h_P)$ will be spent. The unfair competitive environment ("**cronyism**") not only results in spending at the level of investment that is equivalent to the hold-up but also results in the level of investment being *much lower* than the normal hold-up level because it is based on the anticipation that the allocation$1-\lambda$ would be made in the event of losing.

The SOE also spends only the investment level h_S determined by $\alpha_S \lambda Q = g'(h_S)$ in anticipation of a larger allocation of λ or slightly above the investment level h_P of the POE determined by $\alpha_P(1-\lambda)Q = g'(h_P)$, since the investment incentive of the competitor (POE) is lowered and the government's favorable subsidy policy

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could mitigate the feedback effect in heterogeneous tournaments and restore competitive pressure, which would be a beneficial policy for the government (principal). See, Nalebuff and Stiglitz (1983), Gürtler and Kräkel (2010) etc.

(“cronyism”) can in any case reverse the situation for him in the second period.

This artificially produces the result of **“Guo jin min tui”** (the state advances, the private sector retreats, in our paper, the SOE is the winner and the POE is the loser), and imposes a large handicap on the POE α_P, which should have a larger investment incentive, through discriminatory taxation. This policy therefore violates the principle of competition in the sense of allowing the inefficient SOE to win, with very **inefficient consequences**. If this aspect (“cronyism”) exists in "controlled competition,"[34] institutional design should be rectified to create a more equitable competitive environment, thereby **improving efficiency**.[35] The "overly discounted, competition-inhibiting, and discriminatory prize" can be viewed as "government failure”, and should be corrected to build a fair competitive environment and appropriately revive competitive pressure (a motivation function). [36] Summarizing the argument so far, we obtain the following proposition.

[Proposition 10].
In the heterogeneous tournaments with different prizes between the POE and the SOE, the adverse effect due to the “cronyism” (unfair competitive environment) could occur, which would bring about the large decline of competitive pressure and very inefficient consequences, as Figure 8 shows. Institutional design should be rectified to create a more equitable competitive environment, thereby improving efficiency.

5. Conclusion.

This paper analyzes how the government, as a national development strategy, induces incentives or forms of competition or races between multiple companies (between SOEs, between POEs, or between SOEs and POEs) in the long-run, using **a model of dynamic tournaments under incomplete contract situations.** This paper can be

[34] Aghion et al.’s (2004) paper on "endogenous political institution" argues that any policy is more likely to be realized if the veto power or ex-post check and balance over the state leader’s (government’s) reform is weak, or if the degree of power vested in the state leader (government) is strong. They use an “analogy with patent protection” in the cost-benefit analysis to argue that ex-post blocking should be weak in order to induce reform efforts (i.e., innovation) from state leaders, which naturally include the possibilities of implementing not only pro-growth policies but also wrong policies (reforms). Policies by the Chinese Communist regime would be no exception.

[35] In terms of Acemoglu, Laibson, and List (2021), equity and efficiency are not in conflict in this case. Great inequity $\boldsymbol{\theta} < \boldsymbol{\theta}^*$ due to “cronyism” creates distortions by preventing the POE from competing the SOE on a level playing field. When the inequity $\boldsymbol{\theta} < \boldsymbol{\theta}^*$ is very high , there would be a greater benefit of reducing inequity in terms of efficiency.

[36] According to Aghion et al (2004), the key will be whether reforms can be correctly modified because of weak ex-post check and balances. In China, however, a recent constitutional amendment eliminated the term-limit for the presidency (the term of office was previously limited to two terms of ten years). While this will increase incentives for state leaders to reform, it also means that correcting misguided policies (reforms) has become more difficult. Without the correct creation of a level playing field and the proper revival of competitive pressure, the original economic development scenario could also be severely derailed.

considered as **a model analysis of "controlled competition" under "State Capitalism"**, in which **the government participates in the market as an active player,** such as in China, Vietnam, Singapore, and in a broad sense, in Japanese Industrial Policy in the past, within the diversity of differing capitalism including Asian Capitalism. In addition to clarifying the incentive mechanism embedded in this model, we also examined the problems and areas for improvement from the perspective of incentive design. In particular, in **the long-term competition between two heterogeneous companies**, it would be a beneficial policy for the government **if the feedback effect could be mitigated by handicapping the winner and favoring the loser**, thereby **restoring the competitive pressure** that had decreased. At the same time, as **excessive competition-inhibiting discriminatory prizes** ("Cronyism") greatly impede investment incentives for both companies, these can be viewed as a "**government failure**", and thus the institution should be redesigned to correct such obstacles, thereby maintaining appropriate competitive pressures.

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