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THREE ESSAYS ON THE ECONOMICS OF CORRUPTION

A thesis submitted to the Faculty of Graduate and Postdoctoral Studies of the
University of Ottawa in partial fulfillment of the requirements for
the degree of Doctor of Philosophy in Economics

by

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ABSTRACT

THIS THESIS CONTAINS THREE ESSAYS on the economics of corruption. The first essay presents a game-theoretic analysis of the Japanese defense market. The second essay presents a model – formulated from the mechanism design perspective – for analyzing the reemployment of high-ranking Japanese bureaucrats in the private sector. The third essay presents a bribery-bidding game with multiple corrupt bureaucrats and a private firm to analyze the corruption in entry regulation.

The first essay presents a game that incorporates these features of the defense procurement process. The results of the analysis suggest that the government pay for low-quality defense goods at inflated prices. Furthermore, because Japanese firms are shielded from competition and because of the lack of a large foreign market, the Japanese defense industry has no incentive to engage in R&D to improve the quality of its defense goods.

The second essay analyzes the implicit collusive relationship between government and private petroleum companies from the perspective of mechanism design. The game contains an explicit formalization of the implicit collusion between government and the petroleum companies it regulates. It has the structure of an optimal-auction problem – with a retiring bureaucrat as the object of the auction, government as the seller, and private petroleum companies as the potential buyers. This essay provides a necessary and sufficient condition for the direct-revelation mechanism to be truthfully implementable in Bayesian Nash equilibrium, and the characterization of the optimal mechanism for government.

In the third essay, we analyze the corruption in entry regulation that involves an entrepreneur and a track of bureaucrats. First, because of the asymmetry of information, the entrepreneur might not obtain the required permit, although collectively as a group, the joint net payoff of the entrepreneur and the bureaucrats is positive. Second, the entrepreneur might pay the bribes without getting the permit. Third, the model confirms the efficiency wage argument; that is, a higher wage discourages corruption by lowering the probability that bureaucrat will accept bribes for fear of losing their jobs if get caught. More rigorous law enforcement to increase the probability of detection also helps to reduce corruption.

KEYWORDS: Amakudari, Corruption, Bribery, Entry Regulation, Mechanism Design, Defense Procurement

JEL Classification: D02, D44, D45, D73, D82

INTRODUCTION TO THE THESIS

THIS THESIS CONTAINS THREE ESSAYS on the economics of corruption. The first essay presents a game-theoretic analysis of the Japanese defense market. The second essay presents a model – formulated from the mechanism design perspective – for analyzing the reemployment of high-ranking Japanese bureaucrats in the private sector after their retirement from the ministries they used to work for. The third essay presents a bribery-bidding game with multiple corrupt bureaucrats and a private firm to analyze the corruption in entry regulation. Our thesis attempts to answer the questions surrounding corruption in a principal-agent setup under various institutional settings. The micro-level theoretical analysis of corruption is rather limited. Nevertheless, our contribution is mostly how to apply the mechanism design approach to the effect of the corruption under the different institutional settings on efficiency.

In our thesis, we mainly focus on the corruption in a bureaucracy. We adopt a more narrow definition of corruption as the practice according to which public officials abuse their power – in contravention with the law – for personal gain. This concept of “corruption” is adopted by several researchers; see, for instance, Jain (2001). From the point of view of economic theory, corruption is a principal-agent problem in which the principal is the state and the agents are public officials, who abuse the discretionary power granted to the public office in their rent-seeking activities. In order for corruption to take place and flourish, three conditions must exist.¹ First, there must be discretionary power associated with the public office. Second, there must also be economic rents that can be extracted by public officials using the discretionary power associated with the public office. Third, the political, administrative, and legal institutions are weak. The discretionary power available to the public officials makes it difficult to ascertain whether or not the actions they take are in accordance to the rules of the game. Weak institutions allow these officials to escape punishment, even when their corruption

¹ For concrete examples of corruption, De Soto (1989) is a good guide for researchers who are interested in the subject of corruption. He explains how the cumbersome bureaucratic procedures affect the Peruvian market mechanism.

activities are detected. The confluence of these three conditions creates the incentive for public officials to exploit their discretionary power to create or extract rents.

In analyzing corruption, a researcher can classify the actors involved in this kind of activity into three groups:

- elected officials and politicians;
- non-elected officials – bureaucrats, member of the judiciary;
- private agents – individual citizens and firms.

Under this classification, *grand corruption* occurs at the highest levels of government, when all the three groups are involved. Grand corruption occurs in military equipment procurement and subsidies to specific sectors. It involves the highest elected public officials. A good example of grand corruption involved the Japanese Prime Minister Kakuei Tanaka, who received bribes – as payments from the Lockheed Aerospace Corporation in 1976 for his intervention in the purchase of its aircraft by the Japanese government – and was convicted, then sent to jail.² *Influence peddling* occurs between elected officials – politicians and legislators – and private citizens. In industrialized countries like the US or Canada, the bribes often take the form of political campaign contributions made by special-interest groups to obtain favorable legislations or special treatments. *Petty corruption* occurs when private citizens interact with low-level administrative bureaucrats. Examples of petty corruption include bribes paid to bureaucrats by firms to obtain a license to operate a business, an export license, or to carry out some construction work. Other examples of petty corruption often mentioned in the literature for illustrative purposes involve bribes paid by a private citizen to obtain a visa or bribes that a business pays to a tax collector to underreport its tax liabilities. While these analytical approaches are microeconomic-based, there are also studies on corruption that are conducted at the macroeconomic level; see, for example, Johnston (2005). By using country-level statistical indicators and cluster analysis, Johnston classifies countries into four categories that reflect the combinations of market maturity and the stability of the state institutions. The first category, called *influence market corruption*, is often found in mature democracies, in which politicians play an important role in acquiring rents for special-interest groups in exchange for political

² About the Lockheed scandal case, see more detail in Johnson (1986) and Naylor (1998).

contributions – both legally and illegally. The second category, called *elite cartel corruption*, occurs within the reforming democracies. The third category, called *oligarch and clan corruption*, occurs within transitional regimes. The fourth category, called *official mogul corruption*, serves within undemocratic countries. In our thesis, Essays One and Two, according to Johnston's classification, are related to the analysis of *influence market corruption*, while Essay Three is about *official mogul corruption*.

Corruption is a human activity that is pervasive in time and space. Corruption occurs under many forms and is not of recent origin. It is not limited to developing countries or countries making the transition from centrally planned to market economies. Corruption also exists in highly industrialized countries, such as Italy, the United States, Germany, and Japan. An immense literature exists on this subject. The first researcher who looked at corruption from the economic perspective was Rose-Ackerman (1973, 1978, 1999). Throughout the 1990s, important contributions to the economic analysis of corruption were made by Shleifer and Vishny (1992, 1993, 1994a, 1994b, 1998). The evidence of the contributions made by these two researchers can be found in *The Grabbing Hand*, a collection of articles they have written or co-authored with other researchers that they edited in 1998. For a quick introduction to the subject of corruption, the reader can consult the survey articles of Andvig (1991), Ales and Di Tella (1997), Bardhan (1997), Goudie and Stasavage (1998), Tanzi (1998), Rose-Ackerman (1999), Andvig *et al.* (2000), Jain (2001), Aidt (2003), and Mishra (2005). Currently, the study of corruption is also high on the research agenda of the IMF and the World Bank. See, for example, some of the most significant studies that came out of the IMF in *Governance, Corruption, and Economic Performance*, a volume edited by Abed and Gupta (2002). The most recent issues of corruption can be found in *International Handbook on the Economics of Corruption*, a book edited by Rose-Ackerman (2006).

A major part of the economic literature on corruption focuses on petty corruption, especially the problem of bribery and extortion that takes place between a member of the bureaucracy and a private agent who applies for a business license or a passport. Some researchers, such as Leff (1964) and Shleifer and Vishny (1993), argued that in

this type of corruption, bribes play the role of side payments – in the tradition of the Coase theorem – and speeds up the bureaucratic process with the ensuing gain in efficiency. Other researchers, such as Boyko *et al.* (1996) and Rose-Ackerman (1999), hold the opposite view and argue that bribes, which *grease the wheels*, represent a second-best solution. The first-best solution might be to find ways to remove the incentive for this type of corruption. Rose-Ackerman, *op cit.*, further argues that corruption in one area, if tolerated, might spread to other areas, and the overall impact on the economy might be pronounced. Another aspect of corruption is the secrecy that surrounds this practice. Because corruption activities are illegal, real resources must be spent by the participating parties to hide them. This source of inefficiency is one of the main themes in the literature on rents seeking; see, for example, Nitzan (1997), Tollison (1997), and Goulder *et al.* (1997).

ESSAY ONE deals with the heavily regulated Japanese defense market from the game-theoretic perspective. In Japan, firms in the defense industry also produce civilian goods, and the revenues they obtain from defense contracts are quite small relative to the revenues coming from the production of private goods. Because the Japanese constitution prohibits arms export, the Japanese defense industry essentially serves an internal market. Furthermore, defense contracts are not awarded on a competitive basis, and the procurement procedures rely on cost-plus contracts, most of which are carried out at the discretion of the bureaucrats in charge. Information on prices and contracts thus become extremely opaque, which makes it easier for misuse and corruption to flourish. The paper presents a game that incorporates these features of the defense procurement process. First, we show in the benchmark case of non-corruption that the direct revelation mechanism can lead to an *ex post* efficient outcome, stated as Proposition 1. Second, and as stated in Proposition 2, when the bureaucrat in charge of the procurement contract is corrupted, he can increase his income by using the discretion allowed by the public office to extract bribes from the bidding of the government procurement contract of which he is responsible. The results of the analysis suggest that the government pays for low-quality defense goods at inflated prices. In addition, because Japanese firms are shielded from competition, and because of the lack

of a large foreign market, the Japanese defense industry has no incentive to engage in R&D to improve the quality of its defense goods. We also stated, as Proposition 3, that if trade liberalization of arms exports takes place, the lure of foreign profits, and the imperative to be competitive in international markets would induce the firms to propose that the procurement be realized at high quality. In contrast with the case when the firms can only serve the internal market, export liberalization leads to an ex post efficient outcome. Although we focus our analyses on Japanese defense market, our model and its results are more general and could be used to model the corruption in government procurement in much more general context.

ESSAY TWO proposes to analyze the collusive relationship between METI³ and private petroleum companies in Japan. Our analysis, we believe, represents the first attempt to model the interaction between the Japanese petroleum industry and its regulators (METI) from the perspective of the theory of mechanism design. The game presents an explicit formalization of the collusion between METI and the petroleum companies it regulates. Between METI and the private petroleum companies, there is a bilateral cooperative relationship through *amakudari*, a process that is known as the reemployment of elite government officials – in the private or quasi-private sector – after the termination of their public service, a second life for such government officials, as executives in these sectors. In its attempt to find employment for its retiring bureaucrats, METI contacts private petroleum companies and ask them to offer highly remunerative positions to these bureaucrats. A company that offers employment to a retiring bureaucrat might benefit from the influence that the bureaucrat has on METI in its decision to award off-shore drilling rights. The objective of METI is to obtain a highly remunerative position for its retiring bureaucrat without sacrificing too much efficiency. The objective of a private petroleum company is to maximize profits, which depend on the oil drilling rights that the retiring bureaucrat is able to obtain, the remuneration paid to the bureaucrat, and production cost – with production cost being private information. From the standpoint of the ministry, it wants to execute a direct-revelation mechanism under which every petroleum company reveals its types truthfully.

³ Ministry of Economy, Trade, and Industry

Because the type of a petroleum company is private information, it will not reveal its type truthfully without the proper incentive. The game presents the necessary and sufficient conditions for the direct revelation mechanism to be truthfully implementable, and provides a characterization of the optimal mechanism. Proposition 1 presents necessary and sufficient conditions for a social-choice function (for the group constituted by METI and the private petroleum companies) that is Bayesian incentive compatible; satisfies the interim rationality constraint for each of the private oil; and maximizes METI's expected payoff. From our analysis, we find that the remuneration obtained by the retiring bureaucrat in the amakudari auction is in proportion to the expected size of the oil reserve and that a higher weight for the welfare component chosen by METI would lead to a lower expected remuneration for the amakudari, at least for small values of the weight for the welfare component in a numerical example. From these numerical examples, we show that the positive weight of the social welfare component may decrease the expected remuneration of the amakudari. We believe that our analytical framework is applicable in other institutional design contexts. The amakudari process is an interesting problem in its own right and has attracted much attention among political scientists and economists outside Japan. Until recently, many scholars in the west have claimed that the process contributes to the economic development of Japan. The phenomenon is not limited to Japan alone, and can be found in Western countries, like the United States, Germany, and Canada etc., which is commonly known as the *revolving door*.⁴ The amakudari game we formulate can be applied in analyzing the interaction between policy makers and special-interest groups. As such, our analysis contributes to the strand of economic literature known as influence buying pioneered by Grossman and Helpman (2001).

ESSAY THREE presents a game-theoretic model – between an entrepreneur and a track of bureaucrats – to analyze the burdensome process of entry regulation. Based on the path-breaking analysis of the Peruvian entry regulation by De Soto (1990), researchers, such as Djankov et al. (2002), try to find the evidence of the inefficiency caused by

⁴ For an exposition on the buying of influence, see Johnston (2005, Chapter 4), in which case studies and examples of influence market corruption in the United State, Germany and Japan can be found.

cumbersome bureaucratic procedures. Our essay is theoretical in nature and focuses on the corruption in entry regulations that involves multiple bureaucrats from the game-theoretic perspective. We eschew the repeated-game approach adopted by Lambert-Mogilansky et al. (2007), and choose to formulate our model under the framework of mechanism design. Our model is interpreted as the voluntary trading institution that regulates the trade between an entrepreneur and the whole series of the bureaucrats.

In our model settings, an entrepreneur applies for a permit, and the process evolves sequentially on a track of two or more bureaucrats in order to acquire the permits. Since the bureaucrats' non-monetary losses are unknown to the entrepreneur, and only the entrepreneur knows the true realized value of the project, there is an incentive for each player not to reveal his type truthfully to an intermediary. Proposition 1 describes a set of necessary and sufficient conditions for a social-choice function to be Bayesian incentive compatible. Next, we use the theoretical approach of Myerson and Satterthwaite (1983), and prove in Proposition 2 that there is no Bayesian incentive compatible social-choice function that is Bayesian incentive compatible; satisfies the interim individual rationality constraints; and is ex post efficient. We find a second-best mechanism in dominant strategies that maximizes the expected total gains from trade subject to the incentive compatibility constraint, the interim individual rationality constraints, and the expected balanced budget constraint. This result is stated as Proposition 3. We also analyze the effects of the severity of the law enforcement and the impact of higher public-sector wages on the incidence of corruption, and have found that they both help to reduce the level of corruption. These results are stated as Proposition 4. Now in the dominant-strategy game, the budget constraint is only balanced in the expected sense. There is no reason to expect that it is actually balanced under all circumstances. Furthermore, because corruption is an illegal act, and is not conducive to raise social welfare, the actual mismatch between bribe payments and bribe receipts in the dominant-strategy game cannot be solved by appealing to an outside source of financing, say a subsidy. Hence in order for trade to take place a mechanism in which the actual budget is balanced must be found. Such a mechanism is presented in Proposition 5, which describes another game with a Bayesian Nash

equilibrium under which actual bribe payments by the entrepreneur are equal to the sum of actual bribes received by the track of bureaucrats for each possible realization of their types. Because the agreement involving bribe payments and bribe receipts constitutes an implicit contract between the entrepreneur and the track of bureaucrats, there is the possibility that the bureaucrats will take the bribes without delivering the permit. Such a breach of contract is not formalized in our model.

In the concluding remarks at the end of the thesis, we discuss the limitations of our analysis, and point to some possible avenues for future research.

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ESSAY ONE
CORRUPTION IN JAPANESE DEFENSE PROCUREMENT
A GAME-THEORETIC ANALYSIS

1. 1 INTRODUCTION

CORRUPTION HAS MANY forms. It ranges from the petty bureaucratic variety that is connected with issuing licenses or franchising rights to corruption in the police, the judiciary, the legislature, and grand corruption that occurs at the highest office. But no form of corruption is more pervasive than that related to government procurement. Government procurement of goods and services typically accounts for 10-15% of GDP for developed countries, and up to as much as 20% of GDP for developing countries. The amounts involved in individual procurement contracts are often huge, and this offers great opportunities for bribes, kickbacks, and other forms of payoffs. In this paper, we present an analysis of corruption in defense procurement, or more precisely the corruption⁵.

The most basic rule governing the relationship between the government and the defense industry is Article 9 of the Japanese constitution, in which Japan renounces wars and recourse to armed force to resolve conflicts⁶. Based on this national philosophy is a prohibition-in-principle, which is known as *Three Principles on the Prohibition of Arms Export*, a doctrine promulgated by former Prime Minister Sato in 1967. In 1976, the Miki Cabinet updated the weapon embargo list of countries to include practically all countries except the US. Also, because the defense of the Japan is guaranteed by the bilateral security alliance with the US, Japan is not under pressure to develop a weapon

⁵ Readers interested in the research of corruption can consult Rose-Ackerman (1999) who presents a good reference of this subject.

⁶ Article 9 says "Aspiring sincerely to an international peace based on justice and order, the Japanese people forever renounce war as a sovereign right of the nations and the threat or use of force as means of settling international disputes."

technology for its own national security. As a consequence of these guidelines and the rigidity of the security relationship with the US, the Japanese defense industry has lost the opportunity to compete in an outside market, and it exists essentially to serve an internal market. Because of these reasons, the Japanese government has a strong incentive to protect the relatively weak defense industry. The protection given by the government shields Japanese defense companies from foreign competition and creates no incentive for these firms to develop low-cost and high-quality products.

According to the government procurement system in Japan, each ministry can procure from both private and public corporations⁷ under the Account Law (Law No. 35 of 1947),⁸ Cabinet Order related to the budget, Settlement of Account and Accounting (Imperial Ordinance No. 165 of 1947), the Local Autonomy Law (Law No.67 of 1947) and also international rule on procurement procedures (effective January 1, 1996 concluded by WTO)⁹. According to these laws and international agreements, the Japanese procurement system is implemented on the principle of non-discrimination, open, and transparent tendering procedures. In particular, in the Japanese defense industry there are some exceptional features and customs in the procurement systems. To obtain a better idea of the Japanese defense procurement system, let us first present some salient facts about the Japanese defense industry.

In the defense market, the 20 leading companies always acquires the approximately 95% of the budget of Japan Defense Agency¹⁰. Since the mid of 1980s, domestic defense industry occupies 90% of the total production and the rest from foreign procurement, especially from the United States. As a result, the Japanese defense

⁷ Public corporations are the public entities whose objective is to implement government laws and policies. In that sense, they have part of the characteristics of both government and private corporations. In our paper, we do not study the behavior of public corporations although their role in government procurement is quite significant. The reader who is interested in the detailed operation of public corporation, can consult Colignon and Usui (2003, Chapter 4).

⁸ The Account Law specifies that competition will be conducted under open-bid procedures. It also permits the selective or limited tendering procedures in some cases.

⁹ See the detailed report of ADB/OECD Anti-Corruption Initiative for Asia and the Pacific (2004).

¹⁰ The details on the twelve leading Japanese defense companies can be found at <http://www.bis.doc.gov/DefenseIndustrialBasePrograms/OSIES/ExportMarketGuides/PacRimMktGuideIndex.html>.

industry forms an oligopoly market. These firms also produce civilian goods, and the revenues they obtain from defense contracts are quite small relative to the revenues coming from the production of private industrial goods. Furthermore, defense contracts are not awarded on a competitive basis. In many cases, these companies cooperatively work together and share the pies routinely according to government policy implementation and administrative guidelines. The procurement procedures rely on cost-plus contracts, most of which are carried out at the discretion of the bureaucrats in charge. Information on prices and contracts thus become extremely opaque, which makes it easier for misuse and corruption to flourish. In practice, it is enough opportunities to change the result of the tenders and to limit the number of the bidders in the defense procurement. Sometimes companies in the defense industries might be bid-rigging in order to share their pies (in Japanese *Dango*)¹¹. According to the Central Procurement Office (CPO)¹² at Japan's Self-Defense Agency, in 1999, the monetary share of discretionary contracts was 85% of all contracts; the share of contracts by tender was 11%; and the share of general competitive contracts was only 4%. These statistics suggested an extraordinary degree of discretion given to bureaucrats in awarding procurement contracts. Thus it was not surprising to learn that scandals and corruption have plagued the defense industry for many years. As an example of corruption¹³, we might mention that in 1998, the defense agency's procurement division allowed Toyo Communications Equipment, a subsidiary of NEC, one of the largest electronics company in Japan, to slash from \$19.2 million to \$6.6 million the amount it was to pay back to the agency after an investigation revealed Toyo had overcharged it for supplies. In exchange, Toyo allegedly agreed to hire these officials as 'advisors' after they retired (*Amakudari*)¹⁴. Defense companies thus have a strong incentive to pay bureaucrats for favorable treatment on policy and administrative guidelines. For a

¹¹ *Dango* is defined as "an institutionalized system of bid-rigging." (Woodall (1996)). In Japan, there are many scandals in the case of *Dango* in the construction industry. Mamiya (1995) and Woodall (1996) contain good examples of *Dango* cases in the construction industry.

¹² Review of the Central Procurement Office for 1999, <http://www.jda.cpo.jp/>.

¹³ From the Economist (1998).

¹⁴ Translated into English, *Amakudari* means "descend from heaven," which is used to describe the reemployment of elite government officials in the private or quasi-private sector after the termination of their public service. For these government officials, this is the time they begin their second life as an executive in these sectors. See Inoki (1995) and Colignon and Usui (2003).

government official, there is also a strong incentive to secure a post-retirement job. As a consequence of the confluence of self-interests, both defense agency and private companies tend to form the informal and vague network related to the procurement process that exists between them.

This paper presents a game that incorporates these features of the defense procurement process. The results of the analysis suggest that the government pay for low-quality defense goods at inflated prices. Furthermore, because Japanese firms are shielded from competition and because of the lack of a large foreign market, the Japanese defense industry has no incentive to engage in R&D to improve the quality of its defense goods.

Until recently, the research on the relationship between corruption and government procurement is rather scarce. An exception is the pioneering work of Rose-Ackerman (1975), who first shed light on the relationship between the market structure and the contracting process of bribery between private firms and public officials. In this paper, she concentrates on the situation in which a private firm or individual attempts to bribe a government bureaucrat in order to acquire a government contract. Rose-Ackerman describes the situations in which bribery tends to occur, and considers the methods in which incentives for corrupt behavior may be controlled under the proper assumptions. Her results show that the existence of corruption affects the structure of government programs. Burguet and Che (2004) model the competitive bidding process in procurement under the charge of a third party, a bureaucrat, who has the discretion power to manipulate the result of the tendering in exchange for bribes. If the third agent is corrupt and has considerable discretion power, the bribery that he exacts is a heavy burden on the efficient firm. As a result, the existence of bribe competition undermines the efficient allocation of bidding result. Compte et al. (2005) analyze the effect of corruption on the competitive bidding process in procurement. Their model allows for the opportunity of readjustment of bidding by a firm in exchange for a bribe. These researchers demonstrate that the existence of bribery facilitates the collusion in price bidding between firms and results in the bidding price being too high. The Japanese

defense procurement process is heavily regulated by the government and therefore the procurement itself becomes a low-quality and high price situation, we believe that the both ideas of Burguet and Che, *op cit.*, and Compte et al., *op cit.*, are applicable to analyze the corruption that exists in the procurement process in the Japanese defense industry. Their models only consider the closed defence procurement market. We introduce foreign defence procurement to analyze the effect of export liberalization and find that this improves the ex post outcome in comparison to the internal market case.

The main contributions of the paper are as follows. First, we show in the benchmark case of non-corruption that the direct revelation mechanism can lead to an ex post efficient outcome. More precisely, when the bureaucrat in charge of the procurement project is honest, he can ask the firms to reveal their costs, which are private information of the firms. In that case, the firms will report their cost truthfully because this is a weakly dominant strategy. Depending on the costs he receives, the honest bureaucrat will award the procurement contract to the firm with the lower cost. The outcome of this direct revelation – a special case of the Groves-Clarke mechanism – satisfies the participation constraint, and is ex post efficient. These results are stated as Proposition 1. Second and as stated in Proposition 2, when the bureaucrat in charge of the procurement contract is corrupted, he can increase his income by using the discretion allowed by the public office to extract bribes from the bidding of the government procurement contract of which he is responsible. Under the uncertainty of the cost structures of the firms, the corrupted bureaucrat can manipulate the assessment of bidding in exchange for a bribe. We show that under the perfect Bayesian Nash equilibrium the collusion between the corrupted bureaucrat and the bidding firms ensures that all the bids propose a low-quality project at the maximum price that the government is willing to pay for the project. Third, we show that when trade liberalization of arms exports takes place, the lure of foreign profits and the imperative to be competitive in international markets induce the firms to propose that the procurement be realized at high quality. In contrast with the case when the firms can only serve the internal market, export liberalization leads to an ex post efficient outcome. However, the collusion between the corrupted bureaucrat and the bidding firms still

ensures that the government pays the reservation price for the project, and the corrupted bureaucrat still obtains the lion's share of the surplus. It is also worth pointing out that the scenario of exports liberalization is much more pleasant for the bidding firms because now their net payoffs are positive instead of being zero as suggested by the perfect Bayesian equilibrium in the case the firms can only serve the internal market.

This paper is organized as follows. In Section 2, the model of government procurement without corruption is presented. The model of government procurement with corruption is presented in Section 3. In the model of Section 3, the firms serve only the internal market. In Section 4, the model of Section 3 is extended to allow for arms exports. That is, the weapon system developed under the procurement contract can be sold in foreign countries. Section 5 contains some concluding remarks and possible future research avenues.

1.2 THE BENCHMARK: A MODEL OF GOVERNMENT PROCUREMENT WITHOUT CORRUPTION

Two firms – called firm 1 and firm 2 – compete for a procurement contract at a price not exceeding $p^{\max}$. Here $p^{\max}$ represents the government's reservation price, i.e., the highest price that the government is willing to pay for the project. A bid for the procurement contract is evaluated in terms of the price and the quality it proposes. For simplicity, assume that the quality proposed in a bid can be $\underline{q}$ (low quality) or $\bar{q}$ (high quality), with $0 \leq \underline{q} < \bar{q}$. The costs of realizing the project at low quality are assumed to be the same for both firms and will be normalized to be 0. Realizing the project at high quality requires more effort from each firm, and the cost of realizing the project at high quality for firm i it will be denoted by θ_i , $i = 1, 2$. We shall assume that θ_1 and θ_2 are independently drawn from the uniform distribution on the interval $[0, 1]$, and that they are private information. In this section, it is assumed that the public official (the bureaucrat) in charge of evaluating the bids is honest. Under this assumption, the firms have no incentive to curry favor by offering bribes to the bureaucrat. A bid of a firm,

say firm i , in this case is a list (p_i, q_i) , where p_i is the price it charges for realizing the project and q_i is the quality of the realized project. The government's valuation of the bid is assumed to be given by

$$(1) \quad \varphi(p_i, q_i) = q_i - p_i. \text{ }^{15}$$

An allocation rule is a list $((a_1, q_1), (a_2, q_2))$, where $a_i \in \{0, 1\}$, $a_1 + a_2 = 1$, and $q_i \in [\underline{q}, \bar{q}]$, $i = 1, 2$. Here $a_i = 1$ indicates that the contract is awarded to firm i and $a_i = 0$ indicates that firm i does not obtain the contract. Also, q_i refers to the quality of the contract that firm i is required to provide under the allocation rule. Note that q_i becomes superfluous if the contract is not awarded to firm i . Under the allocation rule $((a_1, q_1), (a_2, q_2))$, the gross payoff of the government is given by

$$(2) \quad v_0((a_1, q_1), (a_2, q_2)) = q_i \text{ if } a_i = 1.$$

As for the cost of firm i , it is given by

$$(3) \quad v_i((a_1, q_1), (a_2, q_2) | \theta_i) = -\theta_i \text{ if } a_i = 1, \\ = 0, \text{ otherwise.}$$

The joint payoff for the government and the two firms under the allocation rule $((a_1, q_1), (a_2, q_2))$ is then given by

$$(4) \quad \sum_{i=0}^2 v_i((a_1, q_1), (a_2, q_2)).$$

If only one firm, say firm i , bids for the contract, then obviously it will obtain the contract, i.e., $a_i^*(\theta_i) = 1$. The only issue remaining is the quality of the contract to be realized. If the contract is realized at low quality, then the cost to the firm is 0 and the

¹⁵ This is called the *scoring rule* by the government. For a detailed definition of the scoring rule see Che (1993).

gross payoff of the government is $\underline{q}$. In this case, the joint payoff of the government and the firm is $\underline{q}$. On the other hand, if the quality of the project is to be high, then the cost to the firm is θ_i and the gross payoff to the government is $\bar{q}$. In this case, the joint payoff of the government and the firm is $\bar{q} - \theta_i$. Thus the *ex post efficient allocation* rule for the case of a single bidder is that the firm should be awarded the contract and that the quality of the project will be high, i.e., $q_i^*(\theta_i) = \bar{q}$ if and only if $\theta_i \leq \bar{q} - \underline{q}$.

If both firm bid for the contract, and if $\theta_1 \leq \theta_2$, then without any loss of generality, we can assume that firm 1 will be awarded the contract; that is $a_1^*(\theta_1, \theta_2) = 1$ and $a_2^*(\theta_1, \theta_2) = 0$. Furthermore, under this scenario, the quality of the realized project will be high, i.e., $q_1^*(\theta_1, \theta_2) = \bar{q}$ if and only if $\theta_1 \leq \bar{q} - \underline{q}$, while $q_2^*(\theta_1, \theta_2) \in \{\underline{q}, \bar{q}\}$. On the other hand, if $\theta_1 > \theta_2$, then firm 2 should be awarded the contract; that is $a_1^*(\theta_1, \theta_2) = 0$ and $a_2^*(\theta_1, \theta_2) = 1$. Furthermore, under this scenario, the quality of the realized project will be high, i.e., $q_2^*(\theta_1, \theta_2) = \bar{q}$ if and only if $\theta_2 \leq \bar{q} - \underline{q}$, while $q_1^*(\theta_1, \theta_2) \in \{\underline{q}, \bar{q}\}$.

Now for any $(\theta_1, \theta_2) \in [0,1] \times [0,1]$, let $(a_i^*(\theta_1, \theta_2), q_i^*(\theta_1, \theta_2))_{i=1}^2$ be an *ex post efficient allocation rule*; that is, for any allocation rule $((a_1, q_1), (a_2, q_2))$, we have

$$(5) \quad \sum_{i=0}^2 v_i((a_1, q_1), (a_2, q_2)) \leq \sum_{i=0}^2 v_i((a_i^*(\theta_1, \theta_2), q_i^*(\theta_1, \theta_2))_{i=1}^2)$$

Also, let

$$(6) \quad p_1(\theta_1, \theta_2) = \left[v_0((a_i^*(\theta_1, \theta_2), q_i^*(\theta_1, \theta_2))_{i=1}^2) + v_2((a_i^*(\theta_1, \theta_2), q_i^*(\theta_1, \theta_2))_{i=1}^2 | \theta_2) \right] \\ - \left[v_0(a_2^*(\theta_2), q_2^*(\theta_2)) + v_2(a_2^*(\theta_2), q_2^*(\theta_2) | \theta_2) \right]$$

and

$$(7) \quad p_2(\theta_1, \theta_2) = \left[v_0 \left((a_i^*(\theta_1, \theta_2), q_i^*(\theta_1, \theta_2))_{i=1}^2 \right) + v_1 \left((a_i^*(\theta_1, \theta_2), q_i^*(\theta_1, \theta_2))_{i=1}^2 \middle| \theta_1 \right) \right] \\ - \left[v_0 (a_2^*(\theta_2), q_2^*(\theta_2)) + v_1 (a_2^*(\theta_2), q_2^*(\theta_2) \middle| \theta_1) \right]$$

We interpret $p_i(\theta_1, \theta_2)$ as the transfer received by firm $i, i = 1, 2$, under the allocation rule $(a_i^*(\theta_1, \theta_2), q_i^*(\theta_1, \theta_2))_{i=1}^2$, given the types (θ_1, θ_2) of the two firms. Note that in (6) and (7) we have used $(a_i^*(\theta_i), q_i^*(\theta_i))$ to denote an ex post efficient allocation rule when firm i is the only firm bidding for the contract. We shall let

$$(8) \quad p_0(\theta_1, \theta_2) = -[p_1(\theta_1, \theta_2) + p_2(\theta_1, \theta_2)]$$

denote the (negative) transfer to the government; that is, $-p_0(\theta_1, \theta_2)$ represents the price that the government pays for the procurement contract.

The net payoffs of the government and the two firms under the allocation rule $(a_i^*(\theta_1, \theta_2), q_i^*(\theta_1, \theta_2))_{i=1}^2$ are given, respectively, by

$$(9) \quad u_0 \left((a_i^*(\theta_1, \theta_2), q_i^*(\theta_1, \theta_2))_{i=1}^2 \right) = v_0 \left((a_i^*(\theta_1, \theta_2), q_i^*(\theta_1, \theta_2))_{i=1}^2 \right) + p_0(\theta_1, \theta_2)$$

and

$$(10) \quad u_i \left((a_i^*(\theta_1, \theta_2), q_i^*(\theta_1, \theta_2))_{i=1}^2 \middle| \theta_i \right) = v_i \left((a_i^*(\theta_1, \theta_2), q_i^*(\theta_1, \theta_2))_{i=1}^2 \middle| \theta_i \right) + p_i(\theta_1, \theta_2),$$

($i = 1, 2$).

Now consider the group constituted by the government and the two firms and for each $(\theta_1, \theta_2) \in [0, 1] \times [0, 1]$, let

$$(11) \quad f(\theta_1, \theta_2) = \left((a_i^*(\theta_1, \theta_2), q_i^*(\theta_1, \theta_2))_{i=1}^2, p_0(\theta_1, \theta_2), p_1(\theta_1, \theta_2), p_2(\theta_1, \theta_2) \right)$$

As defined, $f : (\theta_1, \theta_2) \rightarrow f(\theta_1, \theta_2)$ is a social-choice function for the group in question which assigns an ex post efficient allocation rule and a set of transfers – one for each firm – as functions of the type profile of the two firms.

Suppose now that the honest bureaucrat wishes to implement the social-choice function f by a direct revelation mechanism. That is, the bureaucrat asks the two firms to reveal their types, then implements the social-choice function f according to the received type profile (θ_1, θ_2) . A strategy for a firm, say i , is a map $s_i : \theta_i \rightarrow s_i(\theta_i)$ of the unit interval into itself. Here $s_i(\theta_i)$ represents the type it announces under this strategy, given that θ_i is its true type. Because there is no a priori reason for a firm to tell the truth about its type, we might have $s_i(\theta_i) \neq \theta_i$.

A strategy $s_i : \theta_i \rightarrow s_i(\theta_i)$ is *weakly dominant* for firm i if the following condition is satisfied:

For any type θ_i of firm i and any strategy s_j of firm j the following inequality holds for all $\hat{\theta}_i \in [0,1]$:

$$(12) \quad \int u_i \left(\left(a_i^*(s_i(\theta_i), s_j(\theta_j)), q_i^*(s_i(\theta_i), s_j(\theta_j)) \right)_{i=1}^2 \middle| \theta_i \right) d\theta_j \\ \geq \int u_i \left(\left(a_i^*(\hat{\theta}_i, s_j(\theta_j)), q_i^*(\hat{\theta}_i, s_j(\theta_j)) \right)_{i=1}^2 \middle| \theta_i \right) d\theta_j.$$

It is simple to show that $s_i : \theta_i \rightarrow s_i(\theta_i)$ is *weakly dominant* for firm i if the following condition is satisfied:

For any $\theta_i \in [0,1]$ and any $\theta_j \in [0,1]$, the following condition holds for all $\hat{\theta}_i \in [0,1]$:

$$(13) \quad u_i \left(\left(a_i^*(s_i(\theta_i), \theta_j), q_i^*(s_i(\theta_i), \theta_j) \right)_{i=1}^2 \middle| \theta_i \right) \geq u_i \left(\left(a_i^*(\hat{\theta}_i, \theta_j), q_i^*(\hat{\theta}_i, \theta_j) \right)_{i=1}^2 \middle| \theta_i \right).$$

PROPOSITION 1: *The social-choice function $f : (\theta_1, \theta_2) \rightarrow f(\theta_1, \theta_2)$ is truthfully implementable in dominant strategies. That is, for each $i = 1, 2$, the strategy $s_i^*(\theta_i) = \theta_i$ is a weakly dominant strategy for firm i . Furthermore, both firms will be willing to participate in the direct revelation mechanism that implements the social choice function f .*

PROOF: If truth telling is not a dominant for some firm, say firm 1, then there exist $\theta_1, \hat{\theta}_1$, and θ_2 such that

$$(14) \quad \begin{aligned} & v_1 \left(\left(a_i^*(\hat{\theta}_1, \theta_2), q_i^*(\hat{\theta}_1, \theta_2) \right)_{i=1}^2 \middle| \theta_1 \right) + p_1(\hat{\theta}_1, \theta_2) \\ & > v_1 \left(\left(a_i^*(\theta_1, \theta_2), q_i^*(\theta_1, \theta_2) \right)_{i=1}^2 \middle| \theta_1 \right) + p_1(\theta_1, \theta_2). \end{aligned}$$

Using (6), the expression for the transfer received by firm 1, in (14), we obtain

$$(15) \quad \begin{aligned} & v_1 \left(\left(a_i^*(\hat{\theta}_1, \theta_2), q_i^*(\hat{\theta}_1, \theta_2) \right)_{i=1}^2 \middle| \theta_1 \right) \\ & + \left[v_0 \left(\left(a_i^*(\hat{\theta}_1, \theta_2), q_i^*(\hat{\theta}_1, \theta_2) \right)_{i=1}^2 \right) + v_2 \left(\left(a_i^*(\hat{\theta}_1, \theta_2), q_i^*(\hat{\theta}_1, \theta_2) \right)_{i=1}^2 \middle| \theta_2 \right) \right] \\ & - \left[v_0 \left(a_2^*(\theta_2), q_2^*(\theta_2) \right) + v_2 \left(a_2^*(\theta_2), q_2^*(\theta_2) \middle| \theta_2 \right) \right] \\ & > v_1 \left(\left(a_i^*(\theta_1, \theta_2), q_i^*(\theta_1, \theta_2) \right)_{i=1}^2 \middle| \theta_1 \right) \\ & + \left[v_0 \left(\left(a_i^*(\theta_1, \theta_2), q_i^*(\theta_1, \theta_2) \right)_{i=1}^2 \right) + v_2 \left(\left(a_i^*(\theta_1, \theta_2), q_i^*(\theta_1, \theta_2) \right)_{i=1}^2 \middle| \theta_2 \right) \right] \\ & - \left[v_0 \left(a_2^*(\theta_2), q_2^*(\theta_2) \right) + v_2 \left(a_2^*(\theta_2), q_2^*(\theta_2) \middle| \theta_2 \right) \right] \end{aligned}$$

Inequality (15) can be simplified as

$$(16) \quad \begin{aligned} & v_0 \left(\left(a_i^*(\hat{\theta}_1, \theta_2), q_i^*(\hat{\theta}_1, \theta_2) \right)_{i=1}^2 \right) + v_1 \left(\left(a_i^*(\hat{\theta}_1, \theta_2), q_i^*(\hat{\theta}_1, \theta_2) \right)_{i=1}^2 \middle| \theta_1 \right) \\ & + v_2 \left(\left(a_i^*(\hat{\theta}_1, \theta_2), q_i^*(\hat{\theta}_1, \theta_2) \right)_{i=1}^2 \middle| \theta_2 \right) \end{aligned}$$

$$\begin{aligned}
&> v_0 \left((a_i^*(\theta_1, \theta_2), q_i^*(\theta_1, \theta_2))_{i=1}^2 \right) + v_1 \left((a_i^*(\theta_1, \theta_2), q_i^*(\theta_1, \theta_2))_{i=1}^2 \middle| \theta_1 \right) \\
&\quad + v_2 \left((a_i^*(\theta_1, \theta_2), q_i^*(\theta_1, \theta_2))_{i=1}^2 \middle| \theta_2 \right).
\end{aligned}$$

The right side of (16) represents the joint payoff of the government and the two firms when the two firms tell the truth, while the left side represents the joint payoff of the government and the two firms when firm 2 tells the truth and firm 1 announces $\hat{\theta}_1$ as its type. The strict inequality contradicts the fact that the allocation rule $(a_i^*(\theta_1, \theta_2), q_i^*(\theta_1, \theta_2))_{i=1}^2$ is ex post efficient.

To continue, let us show that the social-choice function f satisfies the participation constraints for both firms. Indeed, for firm 1 the net payoff it obtains by participating in the direct revelation mechanism is

$$\begin{aligned}
(17) \quad &u_1 \left((a_i^*(\theta_1, \theta_2), q_i^*(\theta_1, \theta_2))_{i=1}^2 \middle| \theta_1 \right) = v_1 \left((a_i^*(\theta_1, \theta_2), q_i^*(\theta_1, \theta_2))_{i=1}^2 \middle| \theta_1 \right) + p_1(\theta_1, \theta_2) \\
&= v_1 \left((a_i^*(\theta_1, \theta_2), q_i^*(\theta_1, \theta_2))_{i=1}^2 \middle| \theta_1 \right) \\
&+ \left[v_0 \left((a_i^*(\theta_1, \theta_2), q_i^*(\theta_1, \theta_2))_{i=1}^2 \right) + v_2 \left((a_i^*(\theta_1, \theta_2), q_i^*(\theta_1, \theta_2))_{i=1}^2 \middle| \theta_2 \right) \right] \\
&- \left[v_0(a_2^*(\theta_2), q_2^*(\theta_2)) + v_2(a_2^*(\theta_2), q_2^*(\theta_2) \middle| \theta_2) \right]
\end{aligned}$$

When firm 2 is the only firm bidding for the contract, then either (i) $(a_2^*(\theta_2), q_2^*(\theta_2)) = (1, \underline{q})$ or (ii) $(a_2^*(\theta_2), q_2^*(\theta_2)) = (1, \bar{q})$.

In case (i), we have

$$(18) \quad v_0(a_2^*(\theta_2), q_2^*(\theta_2)) + v_2(a_2^*(\theta_2), q_2^*(\theta_2) \middle| \theta_2) = \underline{q}.$$

Now if both firms bid for the contract and the bidding of firm 1 does not change the allocation rule that was adopted when firm 2 is the only bidder, then the quality of the

project is still $\underline{q}$. In this case, the gross payoff of the government is still $\underline{q}$ and the cost incurred by each firm is 0; that is,

$$\begin{aligned}
 (19) \quad & u_1 \left((a_i^*(\theta_1, \theta_2), q_i^*(\theta_1, \theta_2))_{i=1}^2 \middle| \theta_1 \right) = v_1 \left((a_i^*(\theta_1, \theta_2), q_i^*(\theta_1, \theta_2))_{i=1}^2 \middle| \theta_1 \right) \\
 & + \left[v_0 \left((a_i^*(\theta_1, \theta_2), q_i^*(\theta_1, \theta_2))_{i=1}^2 \right) + v_2 \left((a_i^*(\theta_1, \theta_2), q_i^*(\theta_1, \theta_2))_{i=1}^2 \middle| \theta_2 \right) \right] \\
 & - \left[v_0(a_2^*(\theta_2), q_2^*(\theta_2)) + v_2(a_2^*(\theta_2), q_2^*(\theta_2) \middle| \theta_2) \right] \\
 & = 0 + [\underline{q} + 0] - [\underline{q} + 0] = 0,
 \end{aligned}$$

which means that in this case firm 1 is not worse off by participating.

On the other hand, when firm 1 joins firm 2 in bidding for the contract and its action changes the allocation rule that was adopted when firm 2 was the only bidder, then the quality of the project will be high. In this case, the gross payoff of the government is $\bar{q}$ and the cost incurred by firm 1 is θ_1 . Because firm 2 is not awarded the contract, the cost it incurs is 0. The net payoff of firm 1 is then given by

$$\begin{aligned}
 (20) \quad & u_1 \left((a_i^*(\theta_1, \theta_2), q_i^*(\theta_1, \theta_2))_{i=1}^2 \middle| \theta_1 \right) = v_1 \left((a_i^*(\theta_1, \theta_2), q_i^*(\theta_1, \theta_2))_{i=1}^2 \middle| \theta_1 \right) \\
 & + \left[v_0 \left((a_i^*(\theta_1, \theta_2), q_i^*(\theta_1, \theta_2))_{i=1}^2 \right) + v_2 \left((a_i^*(\theta_1, \theta_2), q_i^*(\theta_1, \theta_2))_{i=1}^2 \middle| \theta_2 \right) \right] \\
 & - \left[v_0(a_2^*(\theta_2), q_2^*(\theta_2)) + v_2(a_2^*(\theta_2), q_2^*(\theta_2) \middle| \theta_2) \right] \\
 & = -\theta_1 + [\bar{q} + 0] - [\underline{q} + 0] = -\theta_1 + \bar{q} - \underline{q} \geq 0.
 \end{aligned}$$

Note that the inequality in (20) is due to the following facts. First, the joint payoff of the government and the two firms is $\bar{q} - \theta_1$ when firm 1 also bids. Second, this joint payoff results from an ex post efficient allocation rule. Third, $\underline{q}$ is the joint payoff for the government and the two firms under the allocation rule that awards the contract to firm 2, and the quality of the realized project is low.

In case (ii), we have

$$(21) \quad v_0(a_2^*(\theta_2), q_2^*(\theta_2)) + v_2(a_2^*(\theta_2), q_2^*(\theta_2) | \theta_2) = \bar{q} - \theta_2 \geq \underline{q}.$$

Now if both firms bid for the contract and the bidding of firm 1 does not change the allocation rule that was adopted when firm 2 is the only bidder, then the net payoff of firm 1 is 0. On the other hand, if the entrance of firm 1 into the bidding game changes the allocation rule, then because the quality remains the same at the high level, we must have $\theta_1 \leq \theta_2$. Under this scenario, the net payoff of firm 1 is given by

$$(22) \quad \begin{aligned} & u_1\left(\left(a_i^*(\theta_1, \theta_2), q_i^*(\theta_1, \theta_2)\right)_{i=1}^2 \middle| \theta_1\right) = v_1\left(\left(a_i^*(\theta_1, \theta_2), q_i^*(\theta_1, \theta_2)\right)_{i=1}^2 \middle| \theta_1\right) \\ & + \left[v_0\left(\left(a_i^*(\theta_1, \theta_2), q_i^*(\theta_1, \theta_2)\right)_{i=1}^2\right) + v_2\left(\left(a_i^*(\theta_1, \theta_2), q_i^*(\theta_1, \theta_2)\right)_{i=1}^2 \middle| \theta_2\right) \right] \\ & - \left[v_0(a_2^*(\theta_2), q_2^*(\theta_2)) + v_2(a_2^*(\theta_2), q_2^*(\theta_2) | \theta_2) \right] \\ & = -\theta_1 + [\bar{q} + 0] - [\bar{q} - \theta_2] = \theta_2 - \theta_1 + \bar{q} - \underline{q} > 0. \end{aligned}$$

The strict inequality (22) indicates that in this case firm 1 is strictly better off by participating in the direct revelation mechanism. ■

Proposition 1 is an example of the Groves-Clarke mechanism in the context of procurement auction. The proposition asserts that when the bureaucrat in charge of evaluating the bids is honest, he can use the direct revelation mechanism to elicit the private information, namely the cost of realizing the project at high quality, from each of the firm, then uses the information thus obtained to award the contract to the firm with the lower cost. The transfers proposed by the proposition satisfy the participation constraint and induce each firm to reveal truthfully its type.

1.3 A MODEL OF GOVERNMENT PROCUREMENT WITH CORRUPTION

1.3.1 *The Extensive Form of the Game*

In the preceding section, the bureaucrat is assumed to be honest. In this section, we introduce corruption into the model of government procurement of Section 2. We shall assume that the corrupted bureaucrat – as a civil servant – is paid a regular salary by the state, his employer. Furthermore, he can increase his income by using the discretion permitted by the public office to extract bribes from the firms that bid for the procurement contract of which he is in charge. In abusing his power, the corrupted bureaucrat – through his expertise in evaluating bids – can inflate the quality of a bid, by declaring that the project to be realized by a bid is of high quality when in reality it is of low quality. However, the bureaucrat cannot declare that the quality of a proposed project is low when it is of high quality. There is thus asymmetry in the ability of the bureaucrat to “interpret” the quality of the project proposed in a bid: discretion can be biased upward, not downward. Another action that the model allows the corrupted bureaucrat to take is to inform the firm it favors about the bid of the other firm and allows the former to revise its bid. Because crime and punishment are not our focus in this paper, we shall assume the bureaucrat can abuse his power with impunity. Also, because the objective of the corrupted bureaucrat is to maximize his income, he will favor the firm that offers the higher bribe. The discretion thus allows the corrupted bureaucrat to extract bribes from the bidding firms. Under the scenario we envision, a bid of a firm, say firm i , is a list (p_i, q_i, b_i) , where p_i is the price it charges for realizing the project; q_i is the quality of the realized project the bid proposes; and b_i is the bribe (monetary payoff) the firm offers the corrupted bureaucrat if its bid is chosen.

The game of government procurement is a four-staged game, and its extensive form is as follows. In the first stage, the costs – for the two firms – of realizing the project at high quality are independently drawn from the uniform distribution on the unit interval, and the cost of each firm is its own private information. In the second stage, each firm $i, i = 1, 2$, submits a bid (p_i, q_i, b_i) , based on θ_i , the cost it must incur to realize the

project at high quality. In the third stage, the corrupted bureaucrat evaluates the bids. Let $\hat{q}_i$ be the quality – declared by the corrupted bureaucrat – of the realized project proposed by firm i . The firm with the higher valuation $\hat{q}_i - p_i$ will obtain the contract. Note that a firm, say firm j , might not obtain the contract, even with the help of a bribe, if $q_i - p_i > \bar{q} - p_j$, i.e., the price it charges for the realization of the project is much higher than that of the other firm. Of course, the corrupted bureaucrat will use his discretion to manipulate the qualities associated the projects proposed by the two firms to favor the firm that offers the higher bribe, if this action is possible. We shall assume that a firm only pays the bribe it proposes in its bid if it is awarded the contract. In the fourth stage, the firm that wins the contract pays the promised bribe and realizes the project at the quality level specified in its bid.

1.3.2 The Perfect Bayesian Equilibrium

The following lemma follows from the behavior – allowed by the model – of the corrupted bureaucrat. The lemma asserts that the behavior of the corrupted bureaucrat induces the bidding firms to submit bids that propose to realize the project at low quality.

LEMMA: *It is not optimal for a firm to submit a bid that promises to realize the procurement project at high quality.*

PROOF: We shall prove the lemma by reduction ad absurdum. To this end, suppose that a firm, say firm i , submits a bid $(p_i, \bar{q}, b_i)$. Let (p_j, q_j, b_j) be the bid submitted by firm j , the other firm.

If $b_i > b_j$, then the bureaucrat will favor firm i . Because the quality proposed by firm i is high, there is no need for the corrupted bureaucrat to inflate the quality proposed by firm i . The favorite treatment of firm i takes the form of the corrupted bureaucrat

informing firm i about the bid of firm j , and allows firm i to revise its bid to $(p_i', \bar{q}, b_i)$, with p_i' as the revised bidding price, such that $\bar{q} - p_i' > q_j - p_j$. This action allows the corrupted bureaucrat to offer the procurement contract to firm i officially. The net payoff for firm i is then given by $p_i' - \theta_i - b_i$. Now note that if firm i submits the bid $(p_i, \underline{q}, b_i)$ instead of $(p_i, \bar{q}, b_i)$, then it still wins the contract. In this case, besides informing firm i about the bid of firm j , the corrupted also has to inflate the quality of the project proposed by firm i . The net payoff obtained by firm i under the bid $(p_i, \underline{q}, b_i)$ is then given by $p_i' - b_i > p_i' - \theta_i - b_i$.

On the other hand, if $b_i < b_j$, then firm i will not obtain the procurement contract, because the corrupted bureaucrat will favor firm j under this scenario. By submitting the bid $(p_i, \underline{q}, b_i)$, instead of the bid $(p_i, \bar{q}, b_i)$, firm i still does not obtain the contract, and thus cannot make it worse-off. In the case $b_i = b_j$, there is no reason for the bureaucrat to favor one firm over the other. For simplicity, we shall assume that the corrupted bureaucrat will award the contract to firm 1. Thus, submitting a bid that proposes to realize the procurement project at high quality is not optimal for a firm. ■

The following proposition presents a perfect Bayesian equilibrium¹⁶ for the procurement auction game when the bureaucrat in charge of the procurement contract is corrupted and the firms can only serve the internal market.

PROPOSITION 2: *For each $i = 1, 2$, let $(p_i^*, q_i^*, b_i^*) = (p^{\max}, \underline{q}, p^{\max})$ be the bid submitted by firm i . The combination of strategies $(p_i^*, q_i^*, b_i^*), i = 1, 2$, constitutes a perfect Bayesian equilibrium for the game of corruption in government procurement.*

¹⁶ The definition of Perfect Bayesian equilibrium is found in the Fudenberg and Tirole (1991) p.325.

PROOF: First, note that according to lemma, a firm never submits a bid under which the project will be realized at high quality. Next, suppose that firm j submits the bid $(p_j^*, q_j^*, b_j^*) = (p^{\max}, \underline{q}, p^{\max})$. We claim that $(p_i^*, q_i^*, b_i^*) = (p^{\max}, \underline{q}, p^{\max})$ is a best response for firm i against (p_j^*, q_j^*, b_j^*) . Indeed, if firm i submits the bid (p_i^*, q_i^*, b_i^*) , then it has a fifty-fifty chance of obtaining the contract. Furthermore, because under the bid the bribe is equal to the price of the realized project, firm i will make zero profit. Hence firm i will make zero profit under the bid (p_i^*, q_i^*, b_i^*) . Next, note that if the bid (p_i^*, q_i^*, b_i^*) is not best against (p_j^*, q_j^*, b_j^*) , then there is another bid, say $(p_i, \underline{q}, b_i)$, that gives firm i a positive profit, i.e., $p_i - b_i > 0$. Because $p_i \leq p^{\max}$, when the preceding inequality hold, we must have $b_i < p^{\max}$. However, when $b_i < p^{\max}$, the corrupted bureaucrat will favor firm j and award the procurement contract to this firm, and this results in zero profits for firm i , contradicting the hypothesis that the bid $(p_i, \underline{q}, b_i)$ gives firm i positive profits. ■

Proposition 2 is reminiscent of the famous result of the Bertrand model of competition in which the prices set by the two competing firm are driven down to their common average cost, resulting in zero profit for each firm. In the current context, competition to curry favor from the corrupted bureaucrat leads each firm to give away – as bribe – the entire price of the contract: the corrupted bureaucrat extracts the entire surplus from the co-operation of the bidding firms. Furthermore, the contract is always awarded at the reservation price and the quality of the realized project is always low. The results claimed by Proposition 2 thus contrast sharply with those asserted by Proposition 1 – which asserts that the outcome is efficient when the bureaucrat is honest. In the case of Japanese defense procurement, it is often claimed that insufficient funds allocated to defense spending (one per-cent of GDP) lead to weapons of low quality. What Proposition 2 demonstrates is that the quality is low regardless of the reservation price: the corruption in the procurement process ensures that all the bids propose a low-quality

project at the maximum price that the government is willing to pay for the project. We state this result formally in the following corollary:

COROLLARY: An increase in the reservation price of the procurement project does not raise its quality.

1.4 LIBERALIZATION OF ARMS EXPORTS

In this section, we extend the model formulated in Section 3 by allowing the firm that wins the procurement contract to export the product it develops for the government under the contract. The winning firm now can serve both the internal and foreign markets. We shall not attempt to model explicitly the export market, but simply assuming that the profits made on the export market are equal to $\bar{e} > 0$ if the winning firm realizes the procurement project at high quality and are equal to 0 if the realized project is low quality. Presumably, a low-quality project will not be competitive on the international market and will not bring the firm that develops the product any significant profits. The magnitude of $\bar{e}$ depends, of course, on demand conditions on the international market. For our purpose, we shall assume that $\bar{e}$ is sufficiently high, say $\bar{e} \geq 1$, for a firm to justify the decision of developing a high-quality product to serve the export market. Under this assumption, the bid of a firm always proposes to realize a project of high quality. Because both firms propose to develop a high-quality product, there is no need for the corrupted bureaucrat to inflate the quality proposed by either of these firms. The only action available to the corrupted bureaucrat is to inform the firm that offers the higher bribe the price of the bid submitted by the other firm, and allows the former firm to revise its bidding price.

A bid for firm $i, i = 1, 2$, is now a list $(p_i, \bar{q}, b_i)$. We shall now look for a perfect Bayesian equilibrium of the form $(p_i, \bar{q}, b_i) = (p^{\max}, \bar{q}, -\alpha_i \theta_i + \beta_i)$, where α_i and β_i are positive parameters. To this end, suppose that firm 2 submits a bid of this form, say $(p_2, \bar{q}, b_2) = (p^{\max}, \bar{q}, -\alpha_2 \theta_2 + \beta_2)$. What is the best response of firm 1 to such a bid of

firm 2? To answer this question, suppose that firm 1's cost of realizing the project at high quality is θ_1 . Next, let b_1 be the bribe that firm 1 is contemplating to put in its bid. If θ_2 is firm 2's cost of realizing the project at high quality, then the corrupted bureaucrat will favor firm 1 if $b_1 > b_2 = -\alpha_2\theta_2 + \beta_2$, which implies that $\theta_2 > (\beta_2 - b_1)/\alpha_2$. Given that θ_2 is uniformly distributed on the unit interval $[0,1]$, the probability of such an event is $1 - (\beta_2 - b_1)/\alpha_2$. Furthermore, the net payoff of firm 1 is equal to $[1 - (\beta_2 - b_1)/\alpha_2][p^{\max} - \theta_1 + \bar{e} - b_1]$ if the bribe it offers is sufficient to obtain the favorite treatment by the corrupted bureaucrat. On the other hand if firm 1 does not obtain the procurement contract, then its payoff is 0. Thus the expected payoff of firm 1 if it offers the bribe b_1 is given by $[1 - (\beta_2 - b_1)/\alpha_2][p^{\max} - \theta_1 + \bar{e} - b_1]$, and the optimal bribe for firm 1 is the solution of the following simple maximization problem:

$$(23) \quad \max_{b_1} \frac{1}{\alpha_2} [\alpha_2 - \beta_2 + b_1][p^{\max} - \theta_1 + \bar{e} - b_1]$$

The solution of the maximization problem (21) is

$$(24) \quad \begin{aligned} b_1 &= \frac{1}{2} [\beta_2 - \alpha_2 + p^{\max} - \theta_1 + \bar{e}] \\ &= -\frac{1}{2} \theta_1 + \frac{1}{2} [\beta_2 - \alpha_2 + p^{\max} + \bar{e}] \\ &= -\alpha_1 \theta_1 + \beta_1, \end{aligned}$$

where we have let

$$(25) \quad \alpha_1 = \frac{1}{2}, \quad \beta_1 = \frac{1}{2} [\beta_2 - \alpha_2 + p^{\max} + \bar{e}]$$

For a symmetric perfect Bayesian equilibrium, we have

$$(26) \quad \alpha_1 = \alpha_2 = \frac{1}{2},$$

and

$$(27) \quad \beta_1 = \beta_2 = \frac{1}{2} [\beta_2 - \alpha_2 + p^{\max} + \bar{e}]$$

Using (26) in (27), we obtain

$$(28) \quad \beta_1 = \beta_2 = -\frac{1}{2} + p^{\max} + \bar{e}.$$

We have just established the following proposition:

PROPOSITION 3: *For each $i = 1, 2$, let*

$$(29) \quad b_i(\theta_i) = -\frac{1}{2}\theta_i - \frac{1}{2} + p^{\max} + \bar{e}.$$

Then the combination of strategies $(p_i, q_i, b_i(\theta_i)) = (p^{\max}, \bar{q}, b_i(\theta_i))$, $i = 1, 2$, constitutes a perfect Bayesian equilibrium for the game of government procurement with export liberalization. Under this perfect Bayesian equilibrium, the bribe offered by firm i is given by (29), and its net payoff is given by

$$(30) \quad p^{\max} - \theta_i + \bar{e} - b_i(\theta_i) = \frac{1}{2}(1 - \theta_i).$$

Without considering the morality of arms exports, Proposition 3 offers a much more positive result for all the players – the government, the corrupted bureaucrat, and the bidding firms – in the procurement auction game. The lure of profits in foreign markets and the imperative to be competitive in international markets have induced the bidding firms to propose that the procurement project be realized at high quality, in contrast with the low quality proposed by the bids when the firms can only serve the internal market. Furthermore, as can be seen from (29), the bribe offered by the firm with a lower cost is higher than that offered by the firm with a higher cost, allowing the former firm to win the contract. The perfect Bayesian equilibrium described in Proposition 3 is

thus ex post efficient: the introduction of an export market has changed an inefficient outcome into an efficient one. Also, as can be seen from (30), the profit of the firm that obtains the contract is positive, but decreasing in θ_i for $0 \leq \theta_i < 1$, and this result stands in contrast with the result – asserted by Proposition 2 – that the corrupted bureaucrat extracts the entire surplus generated by the co-operation of the bidding firms when they can only serve the internal market. Also, observe from (29) that the higher is the cost of the firm that obtains the contract, the lower is the bribe received by the corrupted bureaucrat.

1.5 CONCLUSION

Under the special conditions that characterize the current Japanese political system, the Japanese defense industry is an oligopoly, and most of the defense contracts are awarded on a discretion base. In many cases, the defense companies routinely work together – in accordance with government implementation policy and administrative guidelines – to share the procurement pies. In this paper, we have constructed a game-theoretic model to study the Japanese defense market. The main result that emerges from our analysis is that it is the collusion between the corrupted bureaucrat, who is charged with evaluating the bids and award the contract, and the bidding firms and the constraint that these firms can only serve the internal market that is the source of low-quality and high-cost defense goods paid for by the Japanese government. This inefficient state of affair can be removed by liberalizing the exports of arms. The liberalization of arms exports present Japanese defense firms with opportunities for good profits, which are only possible if the quality of their products is sufficiently high to make their products competitive on international markets.

It is often claimed that the low level of defense spending in Japan is responsible for the low quality of the weapons produced in Japan. This is obviously true if the cost of developing a good weapon system exceeds the funds allocated for its development. This feature of the Japanese defense industry can easily incorporated in our model by allowing the cost of realizing the project at high quality to be bounded below, not by 0,

but by a minimum cost level that is significant. Our analysis demonstrates that it is the corruption caused by the lack of transparency in the procurement process – not the low budget of defense spending – that is responsible for the current sorry state of affair. Furthermore, while the liberalization of arms exports presents the firms with an opportunity for greater profits, it also forces the firms to produce high-quality products to be competitive on international markets. From the perspective of economic efficiency, liberalizing arms exports is certainly welfare improving, although considerations of ethics and morality might render this policy questionable.

The models we formulated can be extended in several directions. First, we can reduce the discretion at the disposal of the corrupted bureaucrat. In the model of Burguet and Che, *op cit.*, the corrupted bureaucrat is only allowed to exaggerate the quality proposed by a firm. Compte et al., *op cit.*, model the prices, not the quality, proposed by the bidding firms, and allow the corrupted bureaucrat to communicate to the firm he favors the lowest bid price then letting the favorite firm revise its bid. In our model of corruption, the corrupted bureaucrat can both inflate quality and communicate the lowest bid to the firm that offers the highest bribe. In comparison to the works of these researchers, our model accords the corrupted bureaucrat considerable discretion. Second, our model can be enriched by modeling the export market in more detail and by allowing the firms to bribe foreign officials. Because relative to the Japanese internal market the foreign arms market is large and very competitive, the research in this direction should explain how the uncertainty in the cost structures of the firms affects exports and foreign competition. Third, a component that characterizes bilateral co-operation in R&D can also be added. Finally, our model of corruption can serve as a stepping stone for formulating and analyzing the problem of mechanism design, voiced by various world institutions, such as the IMF and the World Bank, to fight corruption at the global level.

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ESSAY TWO

AMAKUDARI: THE POST-RETIREMENT EMPLOYMENT OF BUREAUCRATS IN JAPAN

2.1 INTRODUCTION

IN JAPANESE, THE TERM *AMAKUDARI* literally means “descent from heaven.”¹⁷ In the area of Japanese economic studies – populated mostly by political scientists and sociologists – amakudari describes the reemployment of elite government officials after the termination of their public service in the private or quasi-private sector, a second life for such government officials, as executives in these sectors. Another meaning of the term amakudari is the retired bureaucrat per se who accepts a high-ranked position in the private sector. This paper presents a game-theoretic analysis of amakudari, the process, from the perspective of mechanism design.

In the field of the analysis of the Japanese economic system, most researchers focus on the informal elements in the rapport between the private sector and the public sector. There are two major informal factors: administrative guidance (*gyōsei shidō*, in Japanese)¹⁸ and informal networks. Informal networks, which include amakudari, are based on the personal relationships between government and private businesses. The informal-personal networks that link the public and private sectors are composed of three major elements: amakudari, school and university ties, and factions based on

¹⁷ Some scholars rigidly classify the system of reemployment of bureaucrats in Japan into two subsystems: *amakudari* (descent from heavens) and *yokosuberi* (side slip). In the *amakudari* subsystem, private firms offer elite bureaucrats executive positions when they retire from their ministries. In the *Yokosuberi* subsystem, the retiring bureaucrat takes up employment in some related public corporations. In this paper, we focus only on the first subsystem. Colignon and Usui (2003) provided a more detailed classification of *amakudari* that consists of four routes; this system of classification includes a class known as *wataridori* (migratory bird), which means that bureaucrats either got two or more reemployments either within the public corporation or in both public and private corporations.

¹⁸ Several scholars have explained the role played by informality of administrative guidance. Interested readers can consult van Rixtel (2002, p. 41-42), who listed several definitions found in the major studies in the interpretation of the administrative guidance.

money. In our paper, we focus only on amakudari, the process, and its impact on resource allocation.

In Japan, each ministry has jurisdiction over particular industrial sectors. Two ministries, METI (Ministry of Economy, Trade, and Industry) and MOF (Ministry of Finance), have wide-ranging jurisdictions and can influence the private sectors through formal and informal controls, such as administrative guidance. In particular, METI often requests private firms to subscribe to a variety of cartel-like agreements or to form a cartel themselves to coordinate investment, production, and prices as a means of reducing excessive competition in order to achieve the objectives of their economic plan. According to Johnson (1974, 1975, 1978, 1982), Calder (1989), Blumenthal (1985), Schaefer (1995), Colignon and Usui (1995, 2001, 2003), Inoki (1995), Kosai (1995), Mabuchi (1995), Drucker (1998), Ogino (1998), and van Rixtel (2002a, 2002b), one of the important informal ways of controlling private firms is the amakudari relationship between firms and the government in Japan. In the context of economic theory, amakudari can be characterized as an implicit mutual beneficial contract between ministries and private firms. In that sense, private corporations have an incentive to receive amakudari bureaucrats from ministries that regulate the market in order to have better access to regulatory information. That is, in the heavily regulated Japanese economy, private corporations are able to increase their capacity to adapt and survive by employing amakudari officials. From the standpoint of a ministry, it can request more amakudari positions from private corporations in return for protecting their sectors by keeping newcomers out of their markets.

Although there is much discussion on the role and merits of amakudari, advocates of the process often argue that amakudari induces better use of human resources, helps improve communication, results in more efficient monitoring, and generates good incentives.¹⁹ Detractors of amakudari, on the other hand, point to amakudari as a form of corruption because of the relationship between the regulator (ministries) and the regulated (private firms).

¹⁹ We introduce these four perspectives from Suzuki (2004)'s research.

JNPC (Japan National Petroleum Corporation) provides a good example of the amakudari process. This public corporation, formerly known as the Japan Development of Petroleum Corporation, is controlled by the Development Section, Petroleum Department of METI's Natural Resources and Energy Agency. It has an intricate interlocking network among private sectors and government.²⁰ JNPC was established as a public corporation for the purpose of both exploiting crude oil wells and ensuring an adequate oil supply for the Japanese domestic petroleum market. After the oil crisis in the 1970s, the objectives of JNPC were enlarged to ensure a sufficient stockpile of petroleum in Japan²¹. JNPC succeeded in increasing Japan's oil reserves and has considerable influence on the Japanese petroleum market. It also carries out oil exploration, an activity that is both costly and risky. The public corporation handed out huge amounts of money to subsidize the related Japanese private corporations in their search for oil. Basically, JNPC and private firms establish a new corporation for the purpose of exploration for oil. If the corporation fails to find oil, it does not need to repay the loan for the cost of exploitation. Since METI has discretion to provide money for oil exploitation, JNPC and private corporations become to be the amakudari placement of METI. That is, both METI and JNPC have discretion in funding and regulating these related private corporations. At the same time, the private corporations are pressured to accept amakudari officials from METI in order to receive funding from METI and JNPC. In reality, seven of the companies affiliated with JNPC provided 14 executive positions to METI retired bureaucrats. It is through METI's supervision of the petroleum industry that allows this ministry to obtain amakudari positions for its retiring bureaucrats in the private petroleum companies.

²⁰ For more detail, see Johnson (1978, Chapter 6) and Colignon and Usui (2003). Another good example can be found in Nakano (1998), who discussed the amakudari scandal involving NTT (Nippon Telephone and Telegraph).

²¹ In 1973, OAPEC (Organization of Arab Petroleum Exporting Countries) announced that it would stop oil shipment to the countries that underpinned Israel in its conflict with Egypt and Syria, the conflict that led to of the Yom Kippur War. The oil embargo resulted in a dramatic hike in the price of oil. Because most of Japan's oil imports came from OAPEC member countries, and because the primary objective of the Japanese government was to secure a stable oil supply for the nation, JNPC was created.

Unfortunately, there are limited studies about amakudari relationships between the private sector and government in Japan from the perspectives of economics, and the few studies that exist deal mainly with the practice in the banking sector. Suzuki (2004) listed four possible perspectives that purport to explain why a private bank offers a top executive position to a retiring bureaucrat. According to the first perspective, the human capital accumulated by an amakudari – through years of working at the MoF or the BoJ – is highly valued by the private bank. While the first perspective puts emphasis on the human resource aspect of amakudari, the second perspective stresses the role played by an amakudari as an unsurpassed channel of communication between the firm and the government. This perspective maintains that it is significantly less costly and more effective to communicate with the government via amakudari executives than to access the bureaucracy anonymously from a distance. The third perspective, suggests that amakudari is used as a form of bureaucratic intervention: the presence of retired MoF or BoJ officials on the boards of private banks could be helpful in the implementation of prudential policy. The last perspective on amakudari contends that the process is a system of rewards for bureaucrats who work hard at the MoF or the BoJ for several decades at relatively low pay. An amakudari position thus represents the second carrier – and a much more lucrative one – for a retired bureaucrat.

Although the four perspectives on amakudari just described have been used either alone or together in explaining the amakudari practice, the rise and collapse of the bubble economy in the mid 1990s have cast doubt on the first two perspectives as explanation for the existence of amakudari. According to Asano and Eto (2003, 2005a, 2005b), *Jusen* is a class of financial institutions that initially specialized in housing loans. During the 1980s, city banks – confronted by a slowdown in lending to blue-chip firms – started providing housing loans at lower mortgage rates than those of *Jusen* companies, and this induced the *Jusen* companies to shift their lending to other industries. When the asset price bubble began to burst at the beginning of 1990, the *Jusen* companies were saddled with non-performing loans. To rescue the *Jusen* companies, the MoF ended up injecting tax payers' money into the rescue plan, and according to the preceding authors “*An embarrassing fact emerged during the*

discussion of the rescue plan in the Diet: with only one exception, all of the presidents of the Jusen companies were retired Ministry of Finance bureaucrats. Moreover, amakudari officials from the MoF occupied a considerable number of managerial positions.” The financial crisis just described dispelled the notion that amakudari executives have valuable expertise and experience in running the business of a private company or the notion that they are embedded in the private banks to monitor their lending practice in accordance with the prudential principle.

The main result that emerges from the empirical analysis of Suzuki is that amakudari is the practice employed by the MoF and the BoJ to find post-retirement positions for their former employees. This conclusion was also reached by van Rixtel (2002, Chapter 8) whose empirical analysis went even farther and suggested that there is collusion between the regulator (MoF) and the regulated (regional private banks). This researcher tested and confirmed the hypothesis that troubled banks are willing to take more risk and are thus more willing to offer amakudari positions to retired MoF bureaucrats, who can use their former connections to persuade supervisory authorities to bend rules and allow them to take risks, such as extending loans to risky industries to restore profitability. For a private bank, offering an amakudari position to a retired bureaucrat is the price it pays for buying influence. Amakudari, seen from this angle, is a form of corruption between the regulator and the regulated.

As mentioned at the beginning of the introduction, amakudari has been an attractive subject for political scientists, sociologists, and foreign scholars. However, the subject has not received much attention from economists. Therefore, that the economic literature on amakudari is very limited, and whatever research on the subject that exists is mainly empirical. Besides the work of van Rixtel and the work of Asano and Eto, already discussed, one might mention the empirical study of Horiuchi and Shimizu (2001) on the long-term relationships between banks and government through the human capital relationship. Using statistical analysis, these authors concluded that the amakudari relationship between the regulator and banks is collusive and weakens the soundness of bank management in Japan. One can also mention the empirical study of

Yamori (1998), who used the expense-preference approach developed by Edward (1977) to analyze the impact of amakudari on the Japanese banking system.

In this paper, we propose to analyze the collusion relationship between METI and private oil companies from the game-theoretic perspective. Our analysis, we believe, represents the first attempt to model the interaction between the Japanese petroleum industry and its regulators from the perspective of mechanism design. In contrast to the work of Asano and Eto, which is a signalling game played between a private bank and its depositors and contains no strategic interaction between the bank and the regulator, our game contains an explicit formalization of the collusion between METI and the petroleum companies it regulates. In our paper, we transform amakudari problem into the optimal auction mechanism design problem. In this auction, METI can act as a monopolist and will use its monopoly power in order to exploit its expected revenue from amakudari. This rent extraction mechanism discourages petroleum companies from understating their types, and therefore encourage them to reveal their types truthfully. But under the asymmetric information about firm's type this mechanism can cause the most efficient private petroleum company not to win the tender. Also, the weight that METI assigns to the welfare component in its utility function plays the screening function to distribute the service of the retiring bureaucrat. In our model, manipulating the welfare component METI can face the trade-off between a higher bribe and a lower probability of finding an amakudari position for its retiring bureaucrat, and the optimal trade-off involves a positive probability that the retiring bureaucrat will not land a job with any of the oil companies involved. We also show that a higher weight for the welfare component would lead to a lower expected remuneration for the amakudari, at least for small values of the weight for welfare component by using numerical examples. That is, when the welfare component rises, the new reservation price faced by each firm is lower, and then induces more firms to enter the amakudari auction.

The paper is organized as follows. In Section 2, the amakudari game, with an explicit formalization of the interaction between METI and petroleum companies are presented.

The game we formulate has the structure of an optimal-auction problem, with the amakudari as the object to be auctioned and METI as the owner of the object. The solution of the game, namely the optimal auction, is given in Section 3. In section 4, we characterize the optimal auction mechanism of the amakudari game. Section 5 contains some concluding remarks and possible future research avenues.

2.2 THE MODEL

2.2.1 Payoffs and Preferences

To fix ideas, suppose that the Ministry of Economy, Trade, and Industry (METI) wants to find an amakudari position for one of its retiring bureaucrats. In the process, METI contacts a number, say N , of private oil companies. In what follows, the private oil companies will be indexed by $i, i = 1, \dots, N$ and METI will be indexed by 0.

Suppose that METI is in the process of awarding offshore drilling rights to one of the private oil companies, and that $\bar{x}$ is the expected size of the potential oil reserve that might be discovered. Now consider a private oil company, say company i , at which the retiring bureaucrat lands an amakudari position. We shall assume that if the retiring bureaucrat lands an amakudari position at the i th private oil company, then he will manage to obtain the offshore drilling rights for this firm. Under this event, the expected profits obtained by the firm is assumed to be given by

$$(1) \quad (p - \gamma_i)\bar{x} = \theta_i\bar{x},$$

where p is the price of oil and γ_i is firm i 's average extraction cost. Note that in (1) we have let $\theta_i = p - \gamma_i$ denote the net price obtained by firm i . It is reasonable to assume that $\bar{x}$ is common knowledge, but γ_i is firm i 's private information. For our purpose, we shall assume that θ_i is drawn from a distribution, say $\Phi_i(\theta_i)$, defined on an interval $\Theta_i = [\underline{\theta}_i, \bar{\theta}_i]$ of the real line. The distribution function $\Phi_i(\theta_i)$ is assumed to be common knowledge, and its density, which is denoted by $\phi_i(\theta_i)$, is assumed to be

continuous and strictly positive on Θ_i . Also, we shall assume that the types $\theta_1, \dots, \theta_N$ are independent.

A *profile of types* for the N private oil companies is a list $\theta = (\theta_i)_{i=1}^N$, with $\theta_i \in \Theta_i$ for $i = 1, \dots, N$. An *alternative* for the group made up of METI and the N private oil companies is a list $a = (q_1, \dots, q_N, b_1, \dots, b_N)$, where $q_i \geq 0, i = 1, \dots, N$, $q_1 + \dots + q_N \leq 1$, and $b_i, i = 1, \dots, N$, are real numbers. Here q_i , for $i \in \{1, \dots, N\}$, represents the probability that the retiring bureaucrat lands an amakudari position at the i th private oil company. The probability that METI fails to find employment for its retiring bureaucrat is thus given by $1 - (q_1 + \dots + q_N)$. In our model, $b_i \geq 0, i = 1, \dots, N$, and can be interpreted as the *salary* (or *bribe offered to METI*) that the i th private oil company proposes to pay the retiring bureaucrat, conditional on the event that it offers the retiring bureaucrat an amakudari position. Of course, if this firm is not willing or not able to offer an amakudari position to the retiring bureaucrat, then it will pay nothing. The expected remuneration of the amakudari under the alternative $a = (q_1, \dots, q_N, b_1, \dots, b_N)$ is thus given by $q_1 b_1 + \dots + q_N b_N$. The set of alternatives is denoted by A .

The expected profit of the i th private oil company – as a function of the alternative chosen $a = (q_0, q_1, \dots, q_N, b_1, \dots, b_N)$ – is given by

$$(2) \quad \begin{aligned} u_i(q_0, \dots, q_N, b_1, \dots, b_N, \theta_1, \dots, \theta_N) &= q_i(\theta_i \bar{x} - b_i) \\ &= q_i \bar{x} \theta_i - q_i b_i. \end{aligned}$$

We shall assume that the private oil companies are risk neutral.

As for METI, it obviously cares about finding employment for the retiring bureaucrat, and this component of METI's utility function can be represented by the remuneration that it obtains for the retiring bureaucrat. It is also reasonable to believe that METI cares about economic efficiency, i.e., the profits – net of bribes – of the private oil companies. For our purpose, we shall assume that the preferences of METI are represented by the following utility function:

$$\begin{aligned}
& u_0(q_1, \dots, q_N, b_1, \dots, b_N, \theta_1, \dots, \theta_N) \\
(3) \quad & = q_1 b_1 + \dots + q_N b_N + \varepsilon [q_1(\theta_1 \bar{x} - b_1) + \dots + q_N(\theta_N \bar{x} - b_N)] \\
& = (1 - \varepsilon)[q_1 b_1 + \dots + q_N b_N] + \varepsilon \bar{x} [q_1 \theta_1 + \dots + q_N \theta_N],
\end{aligned}$$

where $\varepsilon \geq 0$ is a parameter representing the weight that METI assigns to the efficiency component. Note that (3) assigns 1 as the weight of the remuneration component. The objective of METI is to design a mechanism that is Bayesian incentive compatible and that satisfies the interim individual rationality constraints of all the private oil companies to maximize its expected payoff. Also, note that in order for METI to accept the job offer (bribe) offered by an oil company, ε must be strictly less than 1. When $\varepsilon = 0$, the utility function of METI depends only on the expected remuneration of the retiring bureaucrat, and the problem faced by METI is reduced to the traditional problem of designing an auction to maximize the expected revenue. As it stands, (2) allows the net payoffs (net of the bribes) of the bidders to enter the utility function of METI: the seller of the object also cares about the welfare of the buyers. Our model thus can be considered as an extension of the revenue-maximizing auction problem.

2.2.2 Mechanism Design

In this sub-section, we formalize the process adopted by METI in its search for an amakudari position as a problem in mechanism design.

2.2.3 Direct Revelation Mechanism

DEFINITION 1: A *social choice function* for the group made up of METI and the N private oil companies is a map $f : \prod_{i=1}^N \Theta_i \rightarrow A$, where the image of each profile of types $\theta = (\theta_1, \dots, \theta_N) \in \prod_{i=1}^N \Theta_i$ is given by

$$(4) \quad f(\theta) = (q_1(\theta), \dots, q_N(\theta), b_1(\theta), \dots, b_N(\theta)).$$

DEFINITION 2: A *direct-revelation mechanism* is a list $\Gamma = (\Theta_1, \dots, \Theta_N, f)$, where $f : \prod_{i=1}^N \Theta_i \rightarrow A$ is a social choice function. Under the mechanism Γ , METI asks each of the private oil companies to reveal its type. If the announced profile of types is $\theta = (\theta_1, \dots, \theta_N)$, then METI will implement the alternative $f(\theta)$.

The mechanism Γ induces a game of incomplete information in the following manner. For each $i \in \{1, \dots, N\}$, a strategy for the i th private oil company is a map $s_i : \Theta_i \rightarrow \Theta_i$, where $s_i(\theta_i)$ is the type announced by this private oil company when its type is θ_i . If $s_i(\theta_i) = \theta_i$ for each $\theta_i \in \Theta_i$, then s_i is called *truth telling*.

DEFINITION 3: A combination of strategies $(s_i^*)_{i=1}^N$ is a *Bayesian Nash equilibrium* for the mechanism Γ if for each $i \in \{1, \dots, N\}$ and each $\theta_i \in \Theta_i$, the following condition is satisfied:

$$(5) \quad \int u_i(f(s_i^*(\theta_i), s_{-i}^*(\theta_{-i}), \theta_i) d\Phi_{-i}(\theta_{-i}|\theta_i) \geq \int u_i(f(\hat{\theta}_i, s_{-i}^*(\theta_{-i}), \theta_i) d\Phi_{-i}(\theta_{-i}|\theta_i)$$

for all $\hat{\theta}_i \in \Theta_i$.

Note that in (5) we have use the following convention: $\theta_{-i} = (\theta_1, \dots, \theta_{(i-1)}, \theta_{(i+1)}, \dots, \theta_N)$, and $\Phi_{-i}(\theta_{-i})$ is the distribution function of θ_{-i} . Also, $s_{-i} = (s_1, \dots, s_{(i-1)}, s_{(i+1)}, \dots, s_N)$ represents the lists of strategies of the private oil companies other than the i th private oil company.

2.2.2. The Bayesian Incentive Compatible Constraint and the Interim Individual Rationality Constraint

It is well known that without some appropriate restrictions on f the direct revelation mechanism $\Gamma = (\Theta_1, \dots, \Theta_N, f)$ will not work. First, there is no a priori reason to believe that the private oil companies will reveal truthfully their types. Under such a scenario,

the profile of types, say θ , announced by the agents $1, \dots, N$ might not be the true profile of types, and the alternative $f(\theta)$ will not be the alternative METI wishes to implement. Second, a private oil company will not participate in the process unless it obtains at least its reservation payoff. In the parlance of mechanism design, METI can only successfully implement the social choice function $f(\theta)$ if this function is *Bayesian incentive compatible* and satisfies the *interim rationality constraint* for each of the private oil companies.

DEFINITION 4: The social choice function f is *truthfully implementable in Bayesian Nash equilibrium* (or *Bayesian incentive compatible*) if the combination of strategies $(s_i^*)_{i=1}^N$, where s_i^* is truth telling for each $i \in \{1, \dots, N\}$, is a Bayesian Nash equilibrium for the mechanism $\Gamma = (\Theta_1, \dots, \Theta_N, f)$.

Now consider a direct revelation mechanism $\Gamma = (\Theta_1, \dots, \Theta_N, f)$, where

$$f(\theta) = (q_1(\theta), \dots, q_N(\theta), b_1(\theta), \dots, b_N(\theta))$$

is the alternative implemented when θ is the profile of types of the N private oil companies. Next, for each $i \in \{1, \dots, N\}$ and each $\hat{\theta}_i \in [\underline{\theta}_i, \bar{\theta}_i]$, define

$$(6) \quad \bar{b}_i(\hat{\theta}_i) = \int q_i(\hat{\theta}_i, \theta_{-i}) b_i(\hat{\theta}_i, \theta_{-i}) d\Phi_{-i}(\theta_{-i}),$$

and

$$(7) \quad \bar{q}_i(\hat{\theta}_i) = \int q_i(\hat{\theta}_i, \theta_{-i}) d\Phi_{-i}(\theta_{-i}).$$

As defined, $\bar{b}_i(\hat{\theta}_i)$ represents the expected remuneration for the amakudari offered by the i th private oil company under the mechanism Γ , given that it announces $\hat{\theta}_i$ as its type and all the other private oil companies announce their types truthfully. As for $\bar{q}_i(\hat{\theta}_i)$, it represents the probability – under the mechanism Γ – that the retiring bureaucrat lands an amakudari position at the i th private oil company, given that it announces $\hat{\theta}_i$ as its type and all the other private oil companies announce their types truthfully.

The expected profit of the i th private oil company under the mechanism Γ , given that it announces $\hat{\theta}_i$ as its type and all the other private oil companies reveal truthfully their types, is then given by

$$(8) \quad \theta_i \bar{q}_i(\hat{\theta}_i) \bar{x} - \bar{b}_i(\hat{\theta}_i).$$

If the type of the i th private oil company is θ_i and if all the private oil companies reveal their types truthfully, then the expected profit of this firm is given by

$$(9) \quad U_i(\theta_i) = \theta_i \bar{q}_i(\theta_i) \bar{x} - \bar{b}_i(\theta_i).$$

The following proposition, which is a restatement of Proposition 23.D.2 in Mas-Collel, Whinston, and Green (1995), gives necessary and sufficient conditions for a social choice function to be Bayesian incentive compatible.

PROPOSITION 1:

Let $f : \theta \rightarrow f(\theta) = (q_1(\theta), \dots, q_N(\theta), b_1(\theta), \dots, b_N(\theta))$ be a social choice function.

Then f is Bayesian incentive compatible if and only if for each $i \in \{1, \dots, N\}$,

- (i) $\bar{q}_i : \theta_i \rightarrow \bar{q}_i(\theta_i)$ is non-decreasing, and
- (ii) $U_i(\theta_i) = U_i(\underline{\theta}_i) + \bar{x} \int_{\underline{\theta}_i}^{\theta_i} \bar{q}_i(t) dt$ for all $\theta_i \in \Theta_i$.

Let f be a social choice function, and consider the direct revelation mechanism $\Gamma = (\Theta_0, \Theta_1, \dots, \Theta_N, f)$. Suppose that θ_i is the private information of the i th private oil company. Let $\bar{u}_i(\theta_i)$ denote the expected profit obtained by this company if it refuses to participate in the mechanism Γ . Let

$$(10) \quad U_i(\theta_i | f) = \int u_i(f(\theta_i, \theta_{-i}), \theta_i) d\Phi_{-i}(\theta_{-i})$$

denote the *interim expected profit* of the i th private oil company if it participates in the mechanism Γ .

DEFINITION 5: The mechanism $\Gamma = (\Theta_0, \Theta_1, \dots, \Theta_N, f)$ is said to satisfy the *interim individual rationality constraints* if for each $i \in \{1, \dots, N\}$ the following *interim participation constraint* is satisfied:

$$(11) \quad U_i(\theta_i | f) = \int u_i(f(\theta_i, \theta_{-i}), \theta_i) d\Phi_{-i}(\theta_{-i}) \geq \bar{u}_i(\theta_i) \text{ for all } \theta_i \in \Theta_i.$$

2.2.4 The Problem of METI

The problem of METI is to find a social choice function that is both Bayesian incentive compatible and satisfies the interim individual rationality constraints to maximize its expected payoff. To this end, let

$$f : \theta \rightarrow f(\theta) = (q_1(\theta), \dots, q_N(\theta), b_1(\theta), \dots, b_N(\theta))$$

be a social choice function that satisfies both of these rationality constraints, and $\Gamma = (\Theta_1, \dots, \Theta_N, f)$ be the direct revelation mechanism that METI is considering to implement. If the i th private oil company does not participate in the mechanism Γ , then its expected profit is 0. On the other hand, if it participates in the mechanism Γ , then the expected profit it obtains— given its type θ_i — is $U_i(\theta_i) = \theta_i \bar{q}_i(\theta_i) \bar{x} - \bar{b}_i(\theta_i)$. Hence the individual interim rationality constraint for the i th private oil company is

$$(12) \quad U_i(\theta_i) = \theta_i \bar{q}_i(\theta_i) \bar{x} - \bar{b}_i(\theta_i) \geq 0, \text{ for all } \theta_i \in \Theta_i, \quad (i = 1, \dots, N).$$

If $\theta = (\theta_1, \dots, \theta_N)$ is the profile of types, then the expected remuneration received by the amakudari under the social choice function f and conditioned on θ is $\sum_{i=1}^N q_i(\theta) b_i(\theta)$.

The expected remuneration received by the amakudari is then given by

$$(13) \quad \begin{aligned} \int [\sum_{i=1}^N q_i(\theta) b_i(\theta)] d\Phi(\theta) &= \sum_{i=1}^N \int q_i(\theta) b_i(\theta) d\Phi(\theta) \\ &= \sum_{i=1}^N \int [\int q_i(\theta_i, \theta_{-i}) b_i(\theta_i, \theta_{-i}) d\Phi_{-i}(\theta_{-i})] d\Phi_i(\theta_i) \\ &= \sum_{i=1}^N \int \bar{b}_i(\theta_i) d\Phi_i(\theta_i). \end{aligned}$$

Now it follows directly from (9) that the expected remuneration that the i th private oil company offers under the mechanism Γ is given by

$$\begin{aligned}
 \int \bar{b}_i(\theta_i) d\Phi_i(\theta_i) &= \int_{\underline{\theta}_i}^{\bar{\theta}_i} [\theta_i \bar{q}_i(\theta_i) \bar{x} - U_i(\theta_i)] \phi_i(\theta_i) d\theta_i \\
 (14) \quad &= \int_{\underline{\theta}_i}^{\bar{\theta}_i} [\theta_i \bar{q}_i(\theta_i) \bar{x} - U_i(\underline{\theta}_i) - \bar{x} \int_{\underline{\theta}_i}^{\theta_i} \bar{q}_i(t) dt] \phi_i(\theta_i) d\theta_i \\
 &= -U_i(\underline{\theta}_i) + \bar{x} \int_{\underline{\theta}_i}^{\bar{\theta}_i} [\theta_i \bar{q}_i(\theta_i)] \phi_i(\theta_i) d\theta_i - \bar{x} \int_{\underline{\theta}_i}^{\bar{\theta}_i} \left[\int_{\underline{\theta}_i}^{\theta_i} \bar{q}_i(t) dt \right] \phi_i(\theta_i) d\theta_i.
 \end{aligned}$$

Note that the second line of (14) has been obtained with the help of (ii) of Proposition 1. Now using integration by part, we obtain the following expression for the second integral on the third line of (14):

$$(15) \quad \int_{\underline{\theta}_i}^{\bar{\theta}_i} \left[\int_{\underline{\theta}_i}^{\theta_i} \bar{q}_i(t) dt \right] \phi_i(\theta_i) d\theta_i = \int_{\underline{\theta}_i}^{\bar{\theta}_i} \bar{q}_i(\theta_i) d\theta_i - \int_{\underline{\theta}_i}^{\bar{\theta}_i} \bar{q}_i(\theta_i) \Phi_i(\theta_i) d\theta_i.$$

Using (15) in (14), we can rewrite the latter expression as

$$\begin{aligned}
 \int \bar{b}_i(\theta_i) d\Phi_i(\theta_i) &= -U_i(\underline{\theta}_i) + \bar{x} \int_{\underline{\theta}_i}^{\bar{\theta}_i} [\theta_i \bar{q}_i(\theta_i)] \phi_i(\theta_i) d\theta_i \\
 &\quad - \bar{x} \int_{\underline{\theta}_i}^{\bar{\theta}_i} \bar{q}_i(\theta_i) d\theta_i + \bar{x} \int_{\underline{\theta}_i}^{\bar{\theta}_i} \bar{q}_i(\theta_i) \Phi_i(\theta_i) d\theta_i \\
 (16) \quad &= -U_i(\underline{\theta}_i) + \bar{x} \left[\int_{\underline{\theta}_i}^{\bar{\theta}_i} [\theta_i \bar{q}_i(\theta_i)] \phi_i(\theta_i) d\theta_i - \int_{\underline{\theta}_i}^{\bar{\theta}_i} \bar{q}_i(\theta_i) [1 - \Phi_i(\theta_i)] d\theta_i \right] \\
 &= -U_i(\underline{\theta}_i) + \bar{x} \int_{\underline{\theta}_i}^{\bar{\theta}_i} \bar{q}_i(\theta_i) \left[\theta_i - \frac{1 - \Phi_i(\theta_i)}{\phi_i(\theta_i)} \right] \phi_i(\theta_i) d\theta_i.
 \end{aligned}$$

Now using (7), we can rewrite the integral on the last line of (16) as follows:

$$\begin{aligned}
 \int_{\underline{\theta}_i}^{\bar{\theta}_i} \bar{q}_i(\theta_i) \left[\theta_i - \frac{1 - \Phi_i(\theta_i)}{\phi_i(\theta_i)} \right] \phi_i(\theta_i) d\theta_i \\
 (17) \quad &= \int_{\underline{\theta}_1}^{\bar{\theta}_1} \dots \int_{\underline{\theta}_N}^{\bar{\theta}_N} q_i(\theta_1, \dots, \theta_N) \left[\theta_i - \frac{1 - \Phi_i(\theta_i)}{\phi_i(\theta_i)} \right] \left[\prod_{j=1}^N \phi_j(\theta_j) \right] d\theta_N \dots d\theta_1.
 \end{aligned}$$

Using (17) in (16), we obtain the following expression for the expected remuneration that the amakudari receives from the i th private oil company:

$$\begin{aligned}
 \int \bar{b}_i(\theta_i) d\Phi_i(\theta_i) &= -U_i(\underline{\theta}_i) \\
 (18) \quad &+ \bar{x} \int_{\underline{\theta}_1}^{\bar{\theta}_1} \dots \int_{\underline{\theta}_N}^{\bar{\theta}_N} q_i(\theta_1, \dots, \theta_N) \left[\theta_i - \frac{1 - \Phi_i(\theta_i)}{\phi_i(\theta_i)} \right] \left[\prod_{j=1}^N \phi_j(\theta_j) \right] d\theta_N \dots d\theta_1.
 \end{aligned}$$

The expected total remuneration that the amakudari receives from the N private oil companies is under the mechanism Γ is then given by

$$\begin{aligned}
 & \sum_{i=1}^N \int \bar{b}_i(\theta_i) d\Phi_i(\theta_i) \\
 (19) \quad & = \bar{x} \int_{\underline{\theta}_1}^{\bar{\theta}_1} \dots \int_{\underline{\theta}_N}^{\bar{\theta}_N} \left(\sum_{i=1}^N q_i(\theta_1, \dots, \theta_N) \left[\theta_i - \frac{1 - \Phi_i(\theta_i)}{\phi_i(\theta_i)} \right] \right) \left[\prod_{j=1}^N \phi_j(\theta_j) \right] d\theta_N \dots d\theta_1 - \sum_{i=1}^N U_i(\underline{\theta}_i).
 \end{aligned}$$

Note that in (19), we have $U_i(\underline{\theta}_i) \geq 0, i = 1, \dots, N$, due to the interim individual rationality constraints.

The expected payoff of METI, as a function of the social choice function f , is then given by

$$\begin{aligned}
 & V(f) \\
 (20) \quad & = (1 - \varepsilon) \bar{x} \int_{\underline{\theta}_1}^{\bar{\theta}_1} \dots \int_{\underline{\theta}_N}^{\bar{\theta}_N} \left(\sum_{i=1}^N q_i(\theta_1, \dots, \theta_N) \left[\theta_i - \frac{1 - \Phi_i(\theta_i)}{\phi_i(\theta_i)} \right] \right) \left[\prod_{j=1}^N \phi_j(\theta_j) \right] d\theta_N \dots d\theta_1 \\
 & \quad - \sum_{i=1}^N U_i(\underline{\theta}_i) + \varepsilon \bar{x} \int_{\underline{\theta}_1}^{\bar{\theta}_1} \dots \int_{\underline{\theta}_N}^{\bar{\theta}_N} \left(\sum_{i=1}^N \theta_i q_i(\theta_1, \dots, \theta_N) \right) \left[\prod_{j=1}^N \phi_j(\theta_j) \right] d\theta_N \dots d\theta_1 \\
 & = \bar{x} \int_{\underline{\theta}_1}^{\bar{\theta}_1} \dots \int_{\underline{\theta}_N}^{\bar{\theta}_N} \left(\sum_{i=1}^N q_i(\theta_1, \dots, \theta_N) \left[\theta_i - (1 - \varepsilon) \frac{1 - \Phi_i(\theta_i)}{\phi_i(\theta_i)} \right] \right) \left[\prod_{j=1}^N \phi_j(\theta_j) \right] d\theta_N \dots d\theta_1 \\
 & \quad - \sum_{i=1}^N U_i(\underline{\theta}_i).
 \end{aligned}$$

The problem faced by METI is to find a social choice function f that is Bayesian incentive compatible and satisfies the interim individual rationality constraints to maximize (20). When $\varepsilon = 0$, (20) is reduced to the optimal auctions problem analyzed in Mas-Collel, Whinston, and Green (1995, Example 23.F2). The solution of (20) that we present in Section 3 involves some minor modifications of the solution to the optimal auctions problem provided by these authors.

2.3 THE OPTIMAL MECHANISM

To find the optimal mechanism, let $\theta = (\theta_1, \dots, \theta_N)$ be a profile of types announced by the N private oil companies, and consider the following maximization problem:

$$(21) \quad \max_{(q_1, \dots, q_N)} \left(\sum_{i=1}^N q_i \left[\theta_i - (1 - \varepsilon) \frac{1 - \Phi_i(\theta_i)}{\phi_i(\theta_i)} \right] \right)$$

subject to

$$(22) \quad q_i \geq 0, i = 1, \dots, N, \text{ and } q_1 + \dots + q_N \leq 1.$$

The solution of the preceding maximization problem can be found as follows. First, for each $i = 1, \dots, N$ and each $\theta_i \in \Theta_i$, let

$$(23) \quad J_i(\theta_i) = \theta_i - (1 - \varepsilon) \frac{1 - \Phi_i(\theta_i)}{\phi_i(\theta_i)}.$$

In the literature of auction theory, $J_i(\theta_i)$ is known as the *virtual valuation* of the i th private oil company. In what follows, we shall make the following assumption:

ASSUMPTION: For each $i = 1, \dots, N$, (i) the virtual valuation $J_i(\theta_i)$, $\underline{\theta}_i \leq \theta_i \leq \bar{\theta}_i$, is non-decreasing. Furthermore, (ii) $J_i(\underline{\theta}_i) < 0$, and (iii) $J_i(\bar{\theta}_i) > 0$.

Note that if the distribution function $\Phi_i(\theta_i)$ is log-concave, then (i) is satisfied. Indeed, if $\Phi_i(\theta_i)$ is log-concave, then $\phi_i(\theta_i)/(1 - \Phi_i(\theta_i))$ is increasing in θ_i .²² The increasing of $\phi_i(\theta_i)/(1 - \Phi_i(\theta_i))$ implies that $(1 - \Phi_i(\theta_i))/\phi_i(\theta_i)$ is decreasing in θ_i . Hence $J_i(\theta_i)$ is strictly increasing in θ_i if $\Phi_i(\theta_i)$ is log-concave. As for (ii) of the assumption, it is certainly satisfied if $\underline{\theta}_i$ is small. The assumption (ii) is made so that the i th private oil company has a positive probability of making an offer to METI.

²² Interest reader should consult Bergstrom and Bagnoli (2005). They classify a series of theorems that relates log-concavity or log-convexity of probability distribution functions and investigate the features of log-concave probability.

Next, for each profile of types $\theta = (\theta_1, \dots, \theta_N)$, let

$$(24) \quad J(\theta) = \max\{J_1(\theta_1), \dots, J_N(\theta_N)\}.$$

Because for each $i \in \{1, \dots, N\}$ the density function $\phi_i(\theta_i)$, $\underline{\theta}_i \leq \theta_i \leq \bar{\theta}_i$, is continuous and strictly positive, the set of profiles of types θ such that $J_i(\theta_i) = J_j(\theta_j) = J(\theta)$ for two private oil companies i, j , with $i \neq j$, has probability 0, which implies that except for a set of type profiles of probability 0, there is only one index $i \in \{1, \dots, N\}$ such that $J_i(\theta_i) = J(\theta)$. In what follows, we shall let $i^*(\theta)$ denote the element of $\{1, \dots, N\}$ such that $J_{i^*(\theta)}(\theta_{i^*(\theta)}) = J(\theta)$. Then $i^*(\theta)$ is uniquely defined almost everywhere. To be more definite, when $J_i(\theta_i) = J(\theta)$ for two or more values of i – and this event is known to have 0 probability – we can choose $i^*(\theta)$ as the smallest value among them. Thus if $J(\theta) \geq 0$, then the solution of the problem constituted by (21) and (22), say $(q_i^*(\theta))_{i=1}^N$, is given by $q_i^*(\theta) = 1$, if $i = i^*(\theta)$, and $q_i^*(\theta) = 0$, if $i \neq i^*(\theta)$. On the other hand, if $J(\theta) < 0$, then the solution of this constrained maximization problem is $q_i^*(\theta) = 0, i = 1, \dots, N$.

To implement the mechanism that maximizes its expected payoff, METI can use the following procedure. First, ask each private oil company i to reveal its type θ_i . Next, for each $i \in \{1, \dots, N\}$, compute $J_i(\theta_i)$ from the value of θ_i revealed by the i th private oil company. If $J_i(\theta_i) < 0$ for each $i \in \{1, \dots, N\}$, then do not accept any job offer from the private oil companies. If $J_i(\theta_i) \geq 0$ for at least one i , then inform private oil company $i^*(\theta)$ that its offer of an amakudari position to the retiring bureaucrat is approved. Next, METI informs all the private oil companies the following transfer scheme: For $i = i^*(\theta)$, set

$$(25) \quad b_i^*(\theta) = \bar{x} \min\{t \in \Theta_i \mid J_i(t) \geq \max\{0, J_1(\theta), \dots, J_{i-1}(\theta), J_{i+1}(\theta), \dots, J_N(\theta)\}\}.$$

For $i \neq i^*(\theta)$, set

$$(26) \quad b_i^*(\theta) = 0.$$

Now let $f^* : \prod_{i=1}^N \Theta_i \rightarrow A$ be the social choice function defined by

$$(27) \quad f^*(\theta) = (q_1^*(\theta), \dots, q_N^*(\theta), b_1^*(\theta), \dots, b_N^*(\theta)).$$

We have the following proposition:

PROPOSITION 2: *Suppose that for each $i \in \{1, \dots, N\}$ the function $J_i(\theta_i)$, $\underline{\theta}_i \leq \theta_i \leq \bar{\theta}_i$, is non-decreasing and satisfies the inequalities $J_i(\underline{\theta}_i) < 0 < J_i(\bar{\theta}_i)$. Then the direct revelation mechanism $\Gamma^* = (\Theta_1, \dots, \Theta_N, f^*)$, where f^* is defined by (25), (26), and (27), maximizes the expected payoff of METI among the class of direct revelation mechanisms that are Bayesian incentive compatible and satisfy the interim individual rationality constraints.*

PROOF: First, we claim that under the mechanism $\Gamma^* = (\Theta_1, \dots, \Theta_N, f^*)$ truth telling is a dominant strategy for each private oil company. To prove this, let $\theta = (\theta_1, \dots, \theta_N)$ be a profile of types, and consider a private oil company, say i .

If all the other firms tell the truth, is there any incentive for firm i to lie? Suppose that firm i chooses to overstate its type by announcing a type $\hat{\theta}_i > \theta_i$. Then using (i) of the assumption, we can assert that $J_i(\hat{\theta}_i) > J_i(\theta_i)$. Hence if the job offer of firm i is accepted by METI under the type profile $(\theta_1, \dots, \theta_N)$, then it is still accepted by METI under the type profile $(\theta_1, \dots, \hat{\theta}_i, \dots, \theta_N)$. Furthermore, according to (25), the salary offers made to the amakudari are the same under both $(\theta_1, \dots, \theta_N)$ and $(\theta_1, \dots, \hat{\theta}_i, \dots, \theta_N)$. Hence overstating one's type does not raise the payoff of a firm if it is the winner in the auction when it tells the truth. If firm i is not the winner under $(\theta_1, \dots, \theta_i, \dots, \theta_N)$, say $J_i(\theta_i) \leq J(\theta)$, then overstating its type by announcing $\hat{\theta}_i > \theta_i$ might allow firm i to win the auction if $J_i(\hat{\theta}_i) > J(\theta)$. However, under this scenario firm i will have to pay

$$b_i^*(\theta_1, \dots, \hat{\theta}_i, \dots, \theta_N) = \bar{x} \min \{t \in \Theta_i \mid J_i(t) \geq J(\theta) \geq J_i(\theta_i)\} \geq \bar{x} J(\theta_i),$$

and this action will result in a profit that is negative or equal to 0. We have just shown that it does not pay to overstate one's type.

Next, consider the case firm i chooses to understate its type. If firm i is the winner under the type profile $(\theta_1, \dots, \theta_i, \dots, \theta_N)$, and continues to be approved by METI, then its expected payoff is the same as when it tells the truth. However, there is a danger in understating its type: if the understatement is significant, the firm might lose the bid for the amakudari, and ends up earning zero expected payoff. Therefore, understating one's type does not pay if the firm is the winner under the type profile $(\theta_1, \dots, \theta_i, \dots, \theta_N)$. On the other hand, if the firm's offer is not approved by METI, then understating one's type will not change the decision of METI, i.e., if firm i is not a winner under the type profile $(\theta_1, \dots, \theta_i, \dots, \theta_N)$, then it is still not a winner if it chooses to understate its type. The claim is now proved. Hence the social-choice function f^* is Bayesian incentive compatible and satisfies the interim rationality constraint of each of the private oil companies.

To continue with the proof of the proposition, next note that under the mechanism $\Gamma^* = (\Theta_1, \dots, \Theta_N, f^*)$ the expected payoff for the i th private oil company, as a function of the type profile θ , is given by

$$(28) \quad \begin{aligned} u_i(f^*(\theta), \theta) &= q_i^*(\theta)[\theta_i \bar{x} - b_i^*(\theta)] \\ &= q_i^*(\theta)\theta_i \bar{x} - q_i^*(\theta)b_i^*(\theta). \end{aligned}$$

Using the assumption that $J_i(\underline{\theta}_i) < 0$, we can assert that $q_i^*(\underline{\theta}_i, \theta_{-i}) = 0$ for all θ_{-i} , which in turn implies that

$$(29) \quad \begin{aligned} u_i(f^*(\underline{\theta}_i, \theta_{-i}), \theta_{-i}) &= q_i^*(\underline{\theta}_i, \theta_{-i})[\underline{\theta}_i \bar{x} - b_i^*(\underline{\theta}_i, \theta_{-i})] \\ &= 0 \end{aligned}$$

for all θ_{-i} . The expected payoff of firm i when its type is θ_i and when all the private oil companies reveal truthfully their types is then given by

$$(30) \quad \begin{aligned} U_i^*(\theta_i) &= \left| \int q_i^*(\theta_i, \theta_{-i}) d\Phi_{-i}(\theta_{-i}) \right| \theta_i \bar{x} - \int q_i^*(\theta_i, \theta_{-i}) b_i^*(\theta_i, \theta_{-i}) d\Phi_{-i}(\theta_{-i}) \\ &= \bar{q}_i^*(\theta_i) \theta_i \bar{x} - \bar{b}_i^*(\theta_i), \end{aligned}$$

where we have let

$$(31) \quad \bar{q}_i^*(\theta_i) = \int q_i^*(\theta_i, \theta_{-i}) d\Phi_{-i}(\theta_{-i})$$

and

$$(32) \quad \bar{b}_i^*(\theta) = \int q_i^*(\theta_i, \theta_{-i}) b_i^*(\theta_i, \theta_{-i}) d\Phi_{-i}(\theta_{-i}).$$

Using (30), we can then assert that

$$(33) \quad U_i^*(\underline{\theta}_i) = 0, \quad (i = 1, \dots, N).$$

Applying (20), and using and (33), we obtain the following expression for the expected payoff of METI under the direct revelation mechanism $\Gamma^* = (\Theta_1, \dots, \Theta_N, f^*)$:

$$(34) \quad \begin{aligned} V(f^*) &= \int_{\underline{\theta}_1}^{\bar{\theta}_1} \dots \int_{\underline{\theta}_N}^{\bar{\theta}_N} \left(\sum_{i=1}^N q_i^*(\theta_1, \dots, \theta_N) \left[\theta_i - (1 - \varepsilon) \frac{1 - \Phi_i(\theta_i)}{\phi_i(\theta_i)} \right] \right) \left[\prod_{j=1}^N \phi_j(\theta_j) \right] d\theta_N \dots d\theta_1 \\ &\geq \int_{\underline{\theta}_1}^{\bar{\theta}_1} \dots \int_{\underline{\theta}_N}^{\bar{\theta}_N} \left(\sum_{i=1}^N (q_i(\theta_1, \dots, \theta_N) \left[\theta_i - (1 - \varepsilon) \frac{1 - \Phi_i(\theta_i)}{\phi_i(\theta_i)} \right]) \right) \left[\prod_{j=1}^N \phi_j(\theta_j) \right] d\theta_N \dots d\theta_1 \\ &\quad - \sum_{i=1}^N U_i(\underline{\theta}_i) = V(f). \end{aligned}$$

In (34) the inequality follows from the fact that $q_i^*(\theta_1, \dots, \theta_N), i = 1, \dots, N$, constitute the solution of the maximization problem represented by (21) and (22), and the fact that $U_i(\underline{\theta}_i) \geq 0$ for each $i \in \{1, \dots, N\}$. The inequality between $V(f^*) \geq V(f)$ implies that the mechanism $\Gamma^* = (\Theta_1, \dots, \Theta_N, f^*)$ maximizes the expected payoff of METI among the class of mechanisms that are Bayesian incentive compatible and that satisfy the interim rationality constraint of each of the private oil companies. ■

2.4 PROPERTIES OF THE OPTIMAL MECHANISM

As described by Proposition 2, the mechanism that maximizes the expected payoff of METI can be considered as a modified second-price sealed-bid auction in which the winner is the bidder with the highest virtual valuation, who pays, not the value of the bid he submitted, but the lowest possible bid that still allows him to win.

2.4.1 *The Discriminating Nature of the Optimal Mechanism*

For each $i \in I$, let θ_i^o be the value of θ_i such that $J_i(\theta_i^o) = 0$. An oil company, say i , whose type is less than θ_i^o will not participate in the auction. Given the expected size of the oil reserve, θ_i^o can be interpreted as the reservation remuneration of the retiring bureaucrat that METI imposes on firm i . A firm with a type $\theta_i < \theta_i^o$ will not participate in the auction because it is not able to offer the minimum salary to the amakudari required by METI. In the auction, METI is a monopolist and will exploit its monopoly power to maximize its expected payoff. The reservation price θ_i^o is a means through which METI extracts rents from a firm. Without the constraint that a job offer will only have a positive probability of being accepted if $J_i(\theta_i) > 0$, the firms might choose to understate their types, and this action by all the firms will reduce the remuneration of the amakudari. The mechanism that maximizes METI's expected payoff discourages the firms from understating their types, and thus has a positive effect on the remuneration of the amakudari.²³ This practice of extracting rents from the various bidders is not without risk. There is a chance that METI will not be able to find an amakudari position for its retiring bureaucrat, and this event has probability $\prod_i \Phi_i(\theta_i^o) > 0$. Under such an event, the realized payoff of METI will be 0, and this means the mechanism adopted by METI is not ex post efficient. Indeed, if METI accepts the job offer made by the firm with the highest type – if the highest type is positive – then it will earn a positive payoff. In the traditional monopoly model, the monopolist has to find the right trade-off between a lower price and higher sales. In our model, the trade-off faced by METI is between a higher bribe and a lower probability of finding an amakudari position for its retiring bureaucrat, and the optimal trade-off involves a positive probability that the retiring bureaucrat will not land a job with any of the oil companies involved.

²³ Bulow and Roberts (1989) interpret an optimal auction problem by the seller as the monopolist problem with third price-discrimination from the perspectives of mechanism design.

The reservation price $\overset{\circ}{\theta}_i$ will vary across the firms if they are asymmetric. This feature of the mechanism adopted by METI serves to discriminate the firms according to the distributions that characterize their types. For a firm whose type has a distribution function in which most of the possible types are found near the upper end of its support, the values of $\Phi_i(\theta_i)$ and $\phi_i(\theta_i)$ will be low for values of θ_i not close to $\bar{\theta}_i$, and this means that the reservation price $\overset{\circ}{\theta}_i$ will be close to the upper bound of the support of $\Phi_i(\theta_i)$. The high value of $\overset{\circ}{\theta}_i$ serves to discourage firm i from understating its type when its type is high. The mechanism that maximizes METI's expected payoff discourages the firms from understating their types, and thus has a positive effect on METI's expected payoff.

If the oil companies are symmetric, then the optimal mechanism will accept the job offer of the most efficient oil company. However, when there is asymmetry among the firms, the auction might not award the object to the bidder who is the most efficient, and this is another source of ex post inefficiency for the monopolist. As an example of this source of ex post inefficiency, consider the following example due to Myerson (1981). Consider two firms, say i and j ,²⁴ and suppose that θ_i is uniformly distributed on the interval $[\underline{\theta}_i, \bar{\theta}_i]$, while θ_j is uniformly distributed on the interval $[\underline{\theta}_j, \bar{\theta}_j]$. The virtual valuation of firm i is

$$(35) \quad \begin{aligned} J_i(\theta_i) &= \theta_i - (1 - \varepsilon) \frac{1 - \Phi_i(\theta_i)}{\phi_i(\theta_i)} \\ &= (2 - \varepsilon)\theta_i - (1 - \varepsilon)\bar{\theta}_i. \end{aligned}$$

The reservation price faced by firm i is

$$(36) \quad \overset{\circ}{\theta}_i = \frac{(1 - \varepsilon)\bar{\theta}_i}{2 - \varepsilon}.$$

Similarly, for firm j , we have

$$(37) \quad J_j(\theta_j) = (2 - \varepsilon)\theta_j - (1 - \varepsilon)\bar{\theta}_j,$$

²⁴ Two private firms with the 2 highest net prices are drawn from the N private firms, which are ordered by net price.

and

$$(38) \quad \overset{o}{\theta}_j = \frac{(1-\varepsilon)\bar{\theta}_j}{2-\varepsilon}.$$

Note that $\overset{o}{\theta}_j > \overset{o}{\theta}_i$ if $\bar{\theta}_j > \bar{\theta}_i$. That is, the optimal mechanism discriminates against the firm with the higher upper bound on its set of possible types by imposing a higher reservation price on this firm. Furthermore, the retiring bureaucrat will land a job at the private oil company i if

$$(39) \quad (2-\varepsilon)\theta_i - (1-\varepsilon)\bar{\theta}_i > \max\{(2-\varepsilon)\theta_j - (1-\varepsilon)\bar{\theta}_j, 0\},$$

that is, if

$$(40) \quad \theta_i > \max\left\{\theta_j + \frac{1-\varepsilon}{2-\varepsilon}(\bar{\theta}_i - \bar{\theta}_j), \frac{1-\varepsilon}{2-\varepsilon}\bar{\theta}_i\right\}. \quad (i \neq j).$$

In the context of the optimal mechanism private oil company i might accept the retiring bureaucrat from METI and win the offshore drilling right, even if $\theta_i < \theta_j$, so long as (40) is satisfied. The optimal mechanism adopted by METI discriminates against the private oil companies for whom the upper bounds on the estimation of net prices are higher. METI is willing to accept this source of ex post inefficiency because the mechanism encourages a bidder with higher types not to understate its type, but to reveal it truthfully in order to acquire the offshore drilling rights.

The weight that METI assigns to the welfare component in its utility function plays a fundamental role in deciding which firm will obtain the service of the retiring bureaucrat. An increase in ε shifts each of the curves $J_i : \theta_i \rightarrow J_i(\theta_i), i = 1, \dots, N$, and this leads to a decline in the reservation price faced by each firm, which in turn reduces the probability that METI fails to find an amakudari position for the retiring bureaucrat. A rise in ε also increases a more efficient firm to win the auction. Indeed, for two firms, say i and j , with $\theta_j > \theta_i$, we have

$$J_j(\theta_j) - J_i(\theta_i) = (\theta_j - \theta_i) - (1-\varepsilon) \left[\frac{1 - \Phi_j(\theta_j)}{\phi_j(\theta_j)} - \frac{1 - \Phi_i(\theta_i)}{\phi_i(\theta_i)} \right],$$

which is positive if ε is close to 1.

2.4.2 *The Expected Remuneration of the Amakudari*

According to (25), the remuneration obtained by the retiring bureaucrat in the amakudari auction is proportional to the expected size of the oil reserve. Furthermore, because the expected size of the oil reserve that the retiring bureaucrat can deliver to the firm that offers him an amakudari position can be taken as a proxy for his rank in the ministry he used to work, a high-ranking bureaucrat will command a high amakudari position.

The expected remuneration also depends on ε , the weight of the social welfare component in the utility function of METI. Recall that if $\varepsilon = 0$, i.e., if METI gives a zero weight to the social welfare component, then the optimal mechanism maximizes the expected remuneration of the amakudari. A positive value of ε reduces the expected remuneration of the amakudari below its maximum level. An increase in ε , we recall, results in a decline in θ_i^o , which has both a positive and a negative effect on the expected remuneration of the retiring bureaucrat. To see how, consider an event under which the retiring bureaucrat failed to obtain an amakudari position at one of the firms before the rise in ε . After the rise in ε , the new reservation price faced by each firm is lower, and the new virtual valuation of one of the firms might be positive. If this is the case, the retiring bureaucrat will land a job at one of the firms. For an event under which METI managed to find an amakudari position before the rise in ε , it still manages to find an amakudari position for the retiring bureaucrat after the rise in ε . However, now the remuneration paid by the winning firm – due to its lower new reservation price – might be lower than the remuneration it had to pay before the rise in ε . However, we should expect the negative effect to dominate the negative effect when more weight is given to social welfare. That is, a higher weight for the welfare component would lead to a lower expected remuneration for the amakudari, at least for small values of ε . The following example illustrates the intuition of this result.

Suppose that $N = 2$, i.e., only two firms try to obtain the service of the retiring bureaucrat. For simplicity, suppose that θ_1 is uniformly distributed on the interval $[0,1]$, and θ_2 is uniformly distributed on the interval $[0,2]$. Figure 1 depicts the outcome of the mechanism that maximizes the expected payoff of METI.

In the Figure 1, the straight line OAD separate set of possible realizations of (θ_1, θ_2) into two sub-regions. In the sub-region above OAD, we have $J_2(\theta_2) > J_1(\theta_1)$, but in the sub-region below OAD, we have $J_2(\theta_2) < J_1(\theta_1)$. The equation that represents the straight line OAD is $\theta_2(\theta_1) = \theta_1 + (1 - \varepsilon)/(2 - \varepsilon)$, or equivalently as $\theta_1(\theta_2) = \theta_2 - (1 - \varepsilon)/(2 - \varepsilon)$. If (θ_1, θ_2) falls inside the shaded rectangle, neither firm will participate in the amakudari auction, and the realized remuneration of the retiring bureaucrat will be 0 .

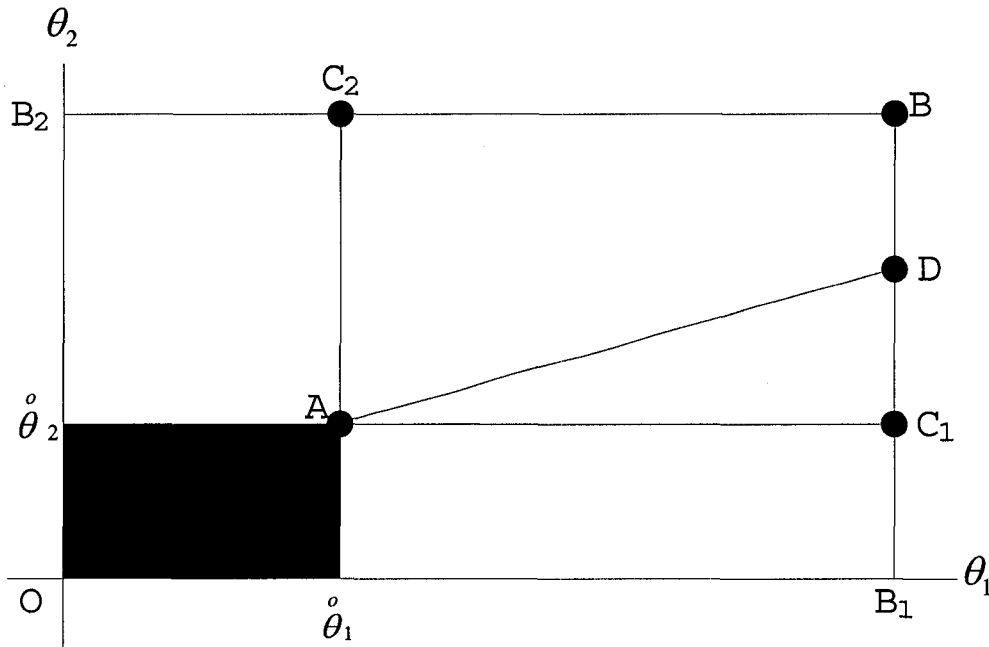


Figure 1.— The outcome of the optimal mechanism

If (θ_1, θ_2) falls inside the rectangle $A\overset{\circ}{\theta}_1 B_1 C_1$, only firm 1 will participate in the amakudari auction, and pays $\overset{\circ}{\theta}_1$ to obtain the service of the retiring bureaucrat. The expected remuneration of the retiring bureaucrat under this event is

$$\begin{aligned} v_1(\varepsilon) &= \frac{1}{2} \overset{\circ}{\theta}_1 (1 - \overset{\circ}{\theta}_1) \overset{\circ}{\theta}_2 \\ &= \frac{(1 - \varepsilon)^2}{(2 - \varepsilon)^3}. \end{aligned}$$

Similarly, when (θ_1, θ_2) falls inside the rectangle $AC_2 B_2 \overset{\circ}{\theta}_2$, only firm 2 will participate in the amakudari auction, and pays $\overset{\circ}{\theta}_2$ to obtain the service of the retiring bureaucrat. The expected remuneration of the retiring bureaucrat under this event is

$$\begin{aligned} v_2(\varepsilon) &= \frac{1}{2} \overset{\circ}{\theta}_1 (2 - \overset{\circ}{\theta}_2) \overset{\circ}{\theta}_2 \\ &= \frac{2(1 - \varepsilon)^2}{(2 - \varepsilon)^3}. \end{aligned}$$

When (θ_1, θ_2) falls inside the triangle $AC_1 D$, both firms will participate in the auction, and the retiring bureaucrat will land a job at firm 1. Under such an event firm 1 will pay

$$\varsigma_1(\theta_2) = \theta_2 - \frac{1 - \varepsilon}{2 - \varepsilon},$$

which is the lowest possible bid that firm 1 could have submitted and still won the auction. The expected remuneration of the retiring bureaucrat under this event is

$$\begin{aligned} v_3(\varepsilon) &= \int_{\overset{\circ}{\theta}_2}^{\varsigma_2(1)} \frac{1}{2} \varsigma_1(\theta_2) [1 - \varsigma_1(\theta_2)] d\theta_2 \\ &= \frac{4 - 3\varepsilon}{12(2 - \varepsilon)^3}. \end{aligned}$$

When (θ_1, θ_2) falls inside the trapeze $ADBC_2$, both firms will participate in the auction, and the retiring bureaucrat will land a job at firm 2. Under such an event firm 2 will pay

$$\varsigma_2(\theta_1) = \theta_1 + \frac{1 - \varepsilon}{2 - \varepsilon},$$

which is the lowest possible bid that firm 2 could have submitted and still won the auction. The expected remuneration of the retiring bureaucrat under this event is

$$\begin{aligned} v_4(\varepsilon) &= \int_{\theta_1}^1 \frac{1}{2} \varsigma_2(\theta_1) [2 - \varsigma_2(\theta_1)] d\theta_1 \\ &= \frac{11 - 9\varepsilon}{6(2 - \varepsilon)^3}. \end{aligned}$$

As a function of ε , the expected remuneration of the amakudari under the optimal mechanism is then given by

$$\begin{aligned} v(\varepsilon) &= \sum_{i=1}^4 v_i(\varepsilon) \\ &= \frac{62 - 93\varepsilon + 36\varepsilon^2}{12(2 - \varepsilon)^3}. \end{aligned}$$

Figure 2 depicts the curve $v(\varepsilon)$, $0 \leq \varepsilon \leq 1$, which is decreasing. In conclusion of this numerical example, we show that a higher weight for the welfare component would lead to a lower expected remuneration for the amakudari, at least for small values of ε .

Expected Remuneration

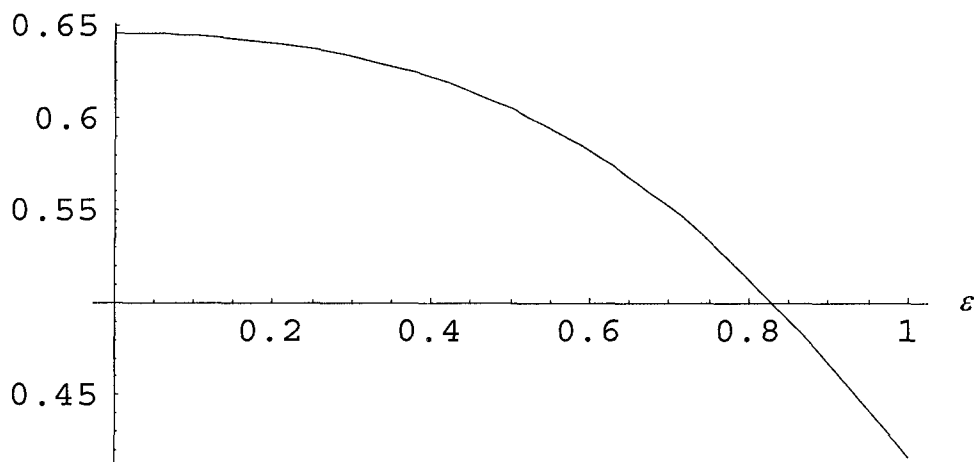


Figure 2.— The expected remuneration of the retiring bureaucrat, as a function of the weight assigned to the welfare component

2.5 CONCLUSION

Although we consider the case studies of amakudari, the reemployment system in Japan, our analytical framework is applicable to other institutional design contexts. The amakudari process is an interesting problem and has attracted much attention among political scientists and economists outside Japan. Many scholars in the west have claimed that the process contributes to the incredible economic development of Japan after the World War II.²⁵ The phenomenon of reemployment is not limited to Japan and can be found in the United States, Germany, and Canada etc. and is commonly known as the *revolving door*.²⁶ The amakudari game we formulate can be applied in analyzing the interaction between policy makers and special-interest groups. As such, our analysis contributes to the strand of economic literature known as influence buying pioneered by Grossman and Helpman (2001). The empirical study by Faccio (2006) investigates the political connection between private firms and government, especially politicians. He uses the data over 20,000 listed companies from 47 countries to empirically investigate the political connection between private companies and governmental sectors. He finds countries with a high level of corruption have strong bonds between private firms and government. In the context of influence buying, our model can be interpreted as the consideration by government to help reduce the cost of private company through bribery in the public procurement setting.

For a long time, the role of amakudari, the second life for the retired bureaucrats, is open to argument among scholars until recent days. Most amakudari analyses are done not by economists but by political scientists and sociologists. In this paper, we propose the optimal amakudari auction model between METI and private oil companies for the first time. The main result that emerges from our analysis is that we transformed amakudari problem into the optimal auction mechanism design problem to maximize the expected remuneration for the retired bureaucrat and the welfare of buyers (private

²⁵ There are several discussions about Japanese miracle economic growth after the War. For interesting readers, see Komiya et al (1988).

²⁶ For an exposition on the buying of influence, see Johnston (2005, Chapter 4), in which case studies and examples of influence market corruption in the United States, Germany and Japan can be found.

oil companies). In that sense, we formulate the game which is similar to the optimal auction problem, with bidding the amakudari bureaucrat as the objectives of getting drilling right for the private oil company and as the seller of the amakudari bureaucrat for METI. Thus, our model seems like an extension of the revenue-maximizing auction problem. Under this optimal auction mechanism, METI can maximize its expected payoff among the class of mechanism that are Bayesian incentive compatible (proposition 1) and that satisfy the interim rationality constraint of each of the private oil companies. By proposition 2, the mechanism that maximizes the expected payoff of METI can be considered as a modified second-price sealed-bid auction. In this auction mechanism, we regard METI as the monopolist to maximize its expected payoff. But at the same time, METI faces the trade-off between higher wage (or bribe) and a lower probability of fining an amakudari position for its retiring bureaucrat. At section 4, we show that the optimal mechanism by METI discriminates against the private oil companies for whom the upper bounds on the estimation of net prices are higher. In that sense, private oil company j has incentive to report honestly if it wants to acquire the offshore drilling right. Also, the weight that METI assigns to the welfare component in its utility function plays the screening function to distribute the service of the retiring bureaucrat. We also show that a higher weight for the welfare component would lead to a lower expected remuneration for the amakudari, at least for small values of the weight for welfare component by using numerical examples.

The models we formulated can be extended in several directions. First, we also extend our analytical methodology to extend the more general cases, while our case is limited to the relationships between private firms and ministry. For example, we also consider the case study of the public cooperation and ministry. Since the public cooperation is regulated by the government (or ministry), we can extend our mechanism design approach in order to analyze the amakudari between public cooperation and ministry. Second, we believe that our approach can help to curb corruption in the bureaucratic system. Our mechanism design approach shows the amakudari as the optimal auction design. From this point of the view, amakudari can be interpreted whether as the distribution of efficient human capital system or as the tools of obtaining the

government procurement. Third, our approach will extend the optimal auction mechanism between the multiple ministries (multiple auctioneers) and multiple private companies. In reality, every ministry has overlapping jurisdictions on the industries. So it is high possibilities for them to ask for multiple private firms to amakudari positions. In that sense, this problem is turned to be the multiple auctioneer and buyers.

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ESSAY THREE
CORRUPTION IN ENTRY REGULATION
A GAME-THEORETIC ANALYSIS WITH A TRACK OF
BUREAUCRATS

3.1 INTRODUCTION

GOVERNMENTS OFTEN REGULATE THE ENTRY into markets by means of permits or licenses. In some countries, the bureaucratic procedures involved in such a process are extremely burdensome. *Red tape*, which includes the process of the acquisition of official permits, licenses, or approvals through multiple ministries, represents considerable expenses for applicants in those countries. When an applicant applies for a government-regulated permit, he often experiences time-consuming and painful procedures associated with the process. To obtain a permit for starting a new business, an entrepreneur often has to complete a number of required procedures and pay numerous fees at various stages of the process. In this paper, we formalize and analyze a game played by an entrepreneur who wants to enter a market and several corrupted bureaucrats who are in charge of regulating the entry of new firms into an industry. The game is formulated from the perspective of mechanism design.

The relationship between economic efficiency and bureaucratic red tape has attracted much attention from scholars working in various disciplines, such as political science, sociology, and economics. A path-breaking study in this subject is *The Other Path* of De Soto (1990), who presented a chronological review of the economic history of Peru, and methodically and analyzed the deficiency of the property law and bureaucratic structure of this country. According to this researcher, to obtain the allocation for a minibus route, an entrepreneur must complete 4 procedures that take him approximately

26 months.²⁷ De Soto also estimated the cost of acquiring formal status of economic activities and compares the choice of applying for formal status and the decision to operate in the informal sector. This researcher concludes that most of the regulations enforced by the Peruvian government are so restrictive to make the development of the market mechanism impossible.

The work of De Soto has inspired several recent empirical studies on the cost of entry generated by administrative barriers. Djankov et al. (2002) described the required procedures of entering a new business, the time, and the cost needed to complete these procedures in 85 countries. These researchers documented that to meet government requirements for starting a business in Bolivia, an entrepreneur must complete 20 different procedures, pay US\$2,696 in fees to the government and wait at least 82 business days to acquire the necessary permits. In contrast, in Canada the process requires only 2 procedures; takes roughly 2 days; and costs the entrepreneur US\$280. Their empirical analysis indicates that the cost of entry is extremely high in most countries. They have also shown that countries with more regulations on entry have higher level of corruption, wider underground economies, and highly inefficient markets. Based on their empirical analysis, these researchers concluded that reality is better described by the grabbing hand than the helping hand.

Morisset and Neso (2002) used a new database to present the effect of administrative barriers in 32 countries. Their database includes several new elements, such as land access, site development, etc. According to their analysis, the level of administrative costs is positively correlated with corruption and negatively correlated with the quality of government, degree of country openness, and public wages. Classens et al. (1999) analyzed the ultimate ownership structure for the 2980 corporations in 9 East Asian countries. In the context of entry regulation, they have also found that heavier regulation is correlated with higher corruption and thus less competition. Using cross-country data, Lambsdorff (2003) verified the negative relationship between corruption and the ratio of investment to GDP. From the results of the recent empirical studies on the negative

²⁷ For a description of the hypothetical access procedure needed to obtain a minibuss route, interest readers can consult De Soto's *The Other Path*, p. 149.

correlation between productivity and corruption, this author attempted to investigate why corruption may cause a negative effect by a variety of government failures. The conclusion this researcher drew from his empirical analysis is that a country's law and order tradition is a key sub-component affecting capital inflows, such as FDI (foreign direct investment).

There are two opposing views on entry regulation by the government that are related to our conceptual research core. Advocates of entry regulation argue that the government must screen new entrants so that they meet minimum standards on health, safety, or the environment, and in the literature on corruption, this argument is known as the *helping hand* theory (Pigou (1938)). The *grabbing-hand* view, on the other hand, sees the government as less benign and regulation as a means used by the government to extract bribes from businesses and consumers.²⁸ As support for this view, proponents of the grabbing-hand theory often point to many regulation procedures that no rational economic criteria can justify (De Sote, op cit., Shleifer and Vishny (1998)). The game that we formulate in our paper reflects the view of the grabbing hand.

According to the grabbing hand view, corruption can be *centralized* or *decentralized* (Bardhan (1997, 2006), Mookherjee (2006)). An example of centralized corruption was the Communist Party in Russia, which centralized the bribe collection system and monitored (with the help of KGB) the deviation of the corrupt agreement. On the other hand, in decentralized corruption, corrupt agents act independently so that there is uncertainty about the number of bribing procedures as well as the number of corrupt agents involved in the bribing game. Post-communism Russia is a good example of decentralized corruption. There are several features that differentiate centralized from decentralized corruption. In centralized corruption, the centralized bribe takers consider the adverse effect of the multiple bribing on total bribe collection. In that sense, the consequences of the centralized corruption might be less harmful than those of

²⁸ The *grabbing-hand* view is also called *tollbooth* theory, which is analogous to tollbooths collecting the tolls on the road. "The independent monopolists solution means that different towns through which the road passes independently erect their own tollbooths and charge their own tolls. " (Shleifer and Vishny (1998), p.100). In the case of administration area, government officials pursue their own benefit instead of maximizing the social welfare.

decentralized corruption. Another distinguishing feature that characterizes decentralized corruption is that a corrupt agent – after taking the bribe – might breach the agreement with briber because of weak law enforcement power, lack property right, and instability of government, etc. In this paper, we share the idea of the decentralized corruption view and construct a theoretical model of entry regulation with multiple agents.

In comparison to the empirical research, the theoretical literature on bureaucratic procedures and corruption is relatively small. There exist several theoretical studies on the relationship between administrative corruption and economic efficiency. Lien (1990) formulated a bribe-bidding procurement game between a corrupt official and two private firms. Under asymmetric information about the manufacturing cost structure and the degree of favor attitude toward firms (called discrimination), each firm chooses a bribery level that corresponds to its own cost level. The analysis of the model indicates that in the presence of discrimination, the corrupt official selects the inefficient allocation, and, as a result, the inefficient allocation may increase the level of discrimination.

Waller et al. (2002) built a principal-agent model of government corruption under several settings to provide a theoretical answer to the question of Bardhan – which is better centralized or decentralized corruption? These researchers suggest that under the regime of a government with high monopoly power and lower public wages, centralized corruption may worsen the level of corruption. According to the model, high public-sector wage help to reduce allocation inefficiency since lower-tier bureaucrats are highly motivated by high wages. Mookherjee and Png (1992) formulated a principal-agent model under the asymmetric information to analyze the optimal compensation policy for a corrupt inspector, who is charged with monitoring pollution from a factory. In their model, the regulator (principal) can neither directly control the inspector's monitoring effort, nor hinder a factory (agent) from bribing an inspector. If bribing is leaked out, the regulator can penalize both the inspector (supervisor) and the factory. In the same spirit as Mookherjee and Png, Guriev (2003, 2004) set up a principal-bureaucrat-agent three-tier model to provide some answers to the questions asked by the former researchers. In the model of Guriev, an agent applies to the government for a

license. The government has its own ideas concerning which type of applicant deserves to have a license, and uses red tape to sort out the bad type (the one who does not deserve a license). If the applicant is of the bad type, he will be willing to pay a large bribe to the bureaucrat to obtain the license. Guriev differentiated two types of corruption – ex ante and ex post corruption. In ex ante corruption, the agent pays speed money to reduce the amount of red tape before the information is produced. In contrast, in ex post corruption the bureaucrat colludes with the agent to conceal the information after the information has been revealed through red tape. To extract bribe from an applicant, a corrupt bureaucrat will generate more red tape to discover the bad type. Thus, the effect of ex post corruption on red tape (more of it) is opposite to that of ex ante corruption (less of it). Guriev showed that the impact on red tape generated by ex post corruption dominates that of ex ante corruption: the equilibrium level of red tape is socially excessive.

Although the literature on corruption is vast, the game-theoretic subset of this literature is rather restrained, and within this subset, the only contribution that deals with multiple bureaucrats is Lambert-Mogilansky et al. (2007). These authors first formalized a game-theoretic model for a single period in which entrepreneurs may apply sequentially to a track of bureaucrats for approval of their projects. A project can only be approved if it is approved by each of the bureaucrats in the track, and each bureaucrat in the track demands a bribe for approval. The single-period game is then repeated indefinitely, with an entrepreneur arriving to face the same track of bureaucrats in each period. To obtain the structure of a repeated game, the values of the projects – assumed to be private information – of the successive entrepreneurs are assumed to be independent and identically distributed random variable. For the single-period game, these researchers showed that there exists no Bayesian Nash equilibrium under which a project is approved with positive probability. When the single-period game is repeated indefinitely the super-game has multiple equilibria in trigger strategies.

We eschew the repeated game approach and choose to formulate our model under the framework of mechanism design. The model we formalize can be considered as a voluntary trading institution that regulates the trade between a buyer (the entrepreneur)

and several sellers (the bureaucrats). As such, the mechanism can represent the bargaining process between the entrepreneur and the bureaucrats who can make offers and counteroffers to each other. The mechanism can also represent an arbitration process in which all parties – entrepreneur and bureaucrats – tell their types to a third party, who will propose whether trade should take place at which prices. Our modeling strategy has several advantages over the repeated game approach. First, it allows us to apply the elegant results of the research on mechanism design developed in the last two decades. Second – and in contrast with the sequential nature of the repeated game approach of Lambert-Mogilansky et al. – our approach allows for a more globally oriented strategy of the entrepreneur. In the single-period model of the researchers just mentioned, the entrepreneur approaches the bureaucrats sequentially, and at any point in time in this process, the entrepreneur will forfeit all the bribes that he has made to the previous bureaucrats if the present bureaucrat refuses to cooperate. Hence it might be in the interest of the entrepreneur to secure a global agreement with all the bureaucrats involved in the process since there is the uncertainty that every track of bureaucrats agreed with the bribery offered by entrepreneur. Entrepreneur prefers the global negotiation with the collected entity which is seemed as all bureaucrats agreed the total amount of bribery to the sequential negotiation with each of bureaucrats because the global strategy can reduce the cost of negotiation. In that sense, this global strategy is captured in our model.

In our model settings, an entrepreneur applies for a permit, and the process evolves sequentially on a track of two or more bureaucrats in order to acquire the permits. Since the bureaucrats' non-monetary losses are unknown to the entrepreneur, and only the entrepreneur knows the true realized value of the project, there is an incentive for each player not to reveal his type truthfully to an intermediary. Proposition 1 describes a set of necessary and sufficient conditions for a social-choice function to be Bayesian incentive compatible. Next, we use the theoretical approach of Myerson and Satterthwaite (1983), and prove in Proposition 2 that there is no Bayesian incentive compatible social-choice function that is Bayesian incentive compatible; satisfies the interim individual rationality constraints; and is ex post efficient. We find a second-best

mechanism in dominant strategies that maximizes the expected total gains from trade subject to the incentive compatibility constraint, the interim individual rationality constraints, and the expected balanced budget constraint. This result is stated as Proposition 3. We also analyze the effects of the severity of the law enforcement and the impact of higher public-sector wages on the incidence of corruption, and have found that they both help to reduce the level of corruption. These results are stated as Proposition 4. Now in the dominant-strategy game, the budget constraint is only balanced in the expected sense. There is no reason to expect that it is actually balanced under all circumstances. Furthermore, because corruption is an illegal act, and is not conducive to raise social welfare, the actual mismatch between bribe payments and bribe receipts in the dominant-strategy game cannot be solved by appealing to an outside source of financing, say a subsidy. Hence in order for trade to take place a mechanism in which the actual budget is balanced must be found. Such a mechanism is presented in Proposition 5, which describes another game with a Bayesian Nash equilibrium under which actual bribe payments by the entrepreneur are equal to the sum of actual bribes received by the track of bureaucrats for each possible realization of their types. Because the agreement involving bribe payments and bribe receipts constitutes an implicit contract between the entrepreneur and the track of bureaucrats, there is the possibility that the bureaucrats will take the bribes without delivering the permit. Such a breach of contract is not formalized in our model.

The essay is organized as follows. In Section 2, we present the entry regulation model, which is a formalization of the interactions between an entrepreneur and a track of bureaucrats in the setting of a direct-revelation mechanism. In section 3, the solution of and a characterization of the mechanism is presented. Section 4 contains some concluding remarks and possible future research avenues.

3.2 THE MODEL

3.2.1 Preferences and Payoffs

An entrepreneur – also called player 0 – has a project whose value is θ_0 if it is realized. The value θ_0 is a random variable drawn from a distribution function $\Phi_0(\theta_0)$, which is defined on an interval $\Theta_0 = [\underline{\theta}_0, \bar{\theta}_0]$ of the real line, where $0 \leq \underline{\theta}_0 < \bar{\theta}_0$. The distribution function $\Phi_0(\theta_0)$ is assumed to be common knowledge and the value of θ_0 is assumed to be the entrepreneur's private information.

In order to realize the project, the entrepreneur must apply for a permit, and the process evolves sequentially on a track of N bureaucrats. The entrepreneur must apply to each bureaucrat in the track in a prescribed order, and the project is approved if and only if it is approved by each bureaucrat. In what follows, bureaucrats are indexed by $i, i = 1, \dots, N$ and the i th bureaucrat will also be referred to as player i .

Let ω_i be the salary of bureaucrat $i, i = 1, \dots, N$. If a bureaucrat, say bureaucrat i , does not accept bribes, then his payoff is simply ω_i . If he is offered a bribe, say b_i , and chooses to accept it, then his payoff will be $\omega_i + b_i$ if he manages to escape detection. On the other hand, if he accepts the bribe and gets caught, then he can expect to lose his job and the bribe to be confiscated. Because bribery is universally shameful, there are also non-monetary losses, such as loss of reputation, loss of family good name, moral costs associated with loss of virtue and integrity.²⁹ We capture these non-monetary losses by a parameter, say θ_i . The value of θ_i is assumed to be drawn from a distribution function $\Phi_i(\theta_i)$, which is defined on an interval $\Theta_i = [\underline{\theta}_i, \bar{\theta}_i]$ of the real line, where $0 \leq \underline{\theta}_i < \bar{\theta}_i$. The distribution function $\Phi_i(\theta_i)$ is assumed to be common

²⁹ For instance, in 1975, corruption was rampant in the Philippine's Bureau of Internal Revenue (BIR). Parts of the BIR employers were embezzling money from tax payer. Justice Efren Plana had responsibilities to reform the corrupted BIR organizations. One of the anti-corruption strategies which Plana did was to convey the information to the mass media if the corrupted BIR official got a criminal charge. Since one's family name is the most sacred in Philippine, his strategy was very effective to curb the corruption in tax correction. These case studies are referred from Klitgaard (1985).

knowledge, and the value of θ_i is assumed to be the private information of bureaucrat i . Also, the distribution functions $\Phi_0, \Phi_1, \dots, \Phi_N$ are assumed to be independent. If the bureaucrat does accept the bribe, then his payoff is given by

$$(1) \quad (1 - p)(\omega_i + b_i) - p\theta_i, \quad (i = 1, \dots, N).$$

In (1), p denotes the probability that the bureaucrat gets caught in the bribery act. The probability p is assumed to be given, and applies to each bureaucrat. The exact value of p reflects the efforts that the law and order authorities expend in fighting corruption, and is not our main concern in this paper.

As for the entrepreneur, if he does not apply for a permit, then his payoff is obviously 0. His payoff is also 0 if he does not obtain the permit. On the other hand, if he pays an amount $-b_0$ to bribe all the bureaucrats in the track, and obtains the permit needed for the realization of the project, then his payoff is

$$(2) \quad \theta_0 + b_0.$$

The one-track model of corruption – one entrepreneur and two or more bureaucrats in the track – can be formulated as a single-period game in extensive form, and the single-period game can then be repeated indefinitely, as in Lambert-Mogilansky et al. (2007). However, we eschew this approach and choose to formulate this game under the framework of mechanism design. Our approach allows for a much richer modelling of the behaviour of bureaucrats than that found in the work of the preceding researchers.

A profile of types for the group made up of the entrepreneur and the N bureaucrats is a list $\theta = (\theta_i)_{i=0}^N$, with $\theta_i \in \Theta_i$ for $i = 0, 1, \dots, N$. An *alternative* for the group is a list $a = (q_0, q_1, \dots, q_N, b_0, b_1, \dots, b_N)$, with the following interpretations. First, q_0 is the probability that the entrepreneur chooses to apply for the permit, and $q_i, i = 1, \dots, N$, is the probability that bureaucrat i approves the project. Second, b_i is a real numbers representing the transfer received by player $i, i = 0, 1, \dots, N$ conditioned on the event that the entrepreneur applies for a permit and the application is approved by each bureaucrat

in the track. Here we follow the convention that $b_i > 0$ indicates a receipt and $b_i < 0$ indicates a payment. In our model, for each $i=1,...,N$, b_i is non-negative, and represents the bribe that the entrepreneur offers to bureaucrat i , while $-b_0$ is non-negative, and represents the total amount that the entrepreneur spends in bribing the N bureaucrat. In equilibrium, we should have $b_0 + b_1 + ... + b_N = 0$. Presumably, if the application is rejected by one of the bureaucrats in the track, then none of them will be offered any bribe. Also, it is obvious that if the entrepreneur chooses not to apply for a permit, then he will not offer any bribe to any bureaucrat in the track. The set of alternatives is denoted by A .

The expected payoff of the i th bureaucrat – as a function of the alternative chosen $a = (q_0, q_1, ..., q_N, b_0, b_1, ..., b_N)$ – is given by

$$\begin{aligned}
 (3) \quad & u_i(q_0, ..., q_N, b_0, ..., b_N, \theta_i) \\
 &= \left(\prod_{j=0}^N q_j \right) [(1-p)(\omega_i + b_i) - p\theta_i] + \left[1 - \left(\prod_{j=0}^N q_j \right) \right] \omega_i \\
 &= \left[- \left(\prod_{j=0}^N q_j \right) p\theta_i \right] + \left[\left(\prod_{j=0}^N q_j \right) (1-p)b_i \right] + \left[\left[1 - \left(\prod_{j=0}^N q_j \right) p \right] \omega_i \right].
 \end{aligned}$$

Note that on the third line of (3) the expression inside the first pair of grand square brackets represents the non-monetary loss for the bureaucrat if he is caught in accepting a bribe; the expression inside the second pair of grand square brackets represents the expected bribe received by the bureaucrat; and the expression inside the third pair of grand square brackets represent the expected labor income that the bureaucrat might enjoy after accounting for the expected income loss if he engages in corrupt behaviour.

As for the entrepreneur, his payoff – as a function of the alternative chosen $a = (q_0, q_1, ..., q_N, b_0, b_1, ..., b_N)$ – is given by

$$(4) \quad u_0(q_0, ..., q_N, b_0, ..., b_N, \theta_0) = \left[\left(\prod_{i=0}^N q_i \right) (1-p) \right] [\theta_0 + b_0]$$

3.2.2 Mechanism Design

In this sub-section, we formalize the collective-choice problem for the group constituted by the entrepreneur and the bureaucrats in the track from whom he seeks approval for his project.

3.2.3 Direct Revelation Mechanism

DEFINITION 1: A *social choice function* for the group made up of the entrepreneur and the bureaucrats in the track is a map $f : \prod_{i=0}^N \Theta_i \rightarrow A$, where the image of each profile of types $\theta = (\theta_0, \theta_1, \dots, \theta_N) \in \prod_{i=0}^N \Theta_i$ is given by

$$(5) \quad f(\theta) = (q_0(\theta), q_1(\theta), \dots, q_N(\theta), b_0(\theta), b_1(\theta), \dots, b_N(\theta)).$$

DEFINITION 2: A *direct revelation mechanism* is a list $\Gamma = (\Theta_0, \Theta_1, \dots, \Theta_N, f)$, where $f : \prod_{i=0}^N \Theta_i \rightarrow A$ is a social choice function. Under the mechanism Γ , a mediator asks each of the players to reveal his type. If the announced profile of types is $\theta = (\theta_0, \theta_1, \dots, \theta_N)$, then the mediator will implement the alternative $f(\theta)$.

The mechanism Γ induces a game of incomplete information in the following manner. For each $i \in \{0, 1, \dots, N\}$, a strategy for the i th player is a map $s_i : \Theta_i \rightarrow \Theta_i$, where $s_i(\theta_i)$ is the type announced by this player when his type is θ_i . If $s_i(\theta_i) = \theta_i$ for each $\theta_i \in \Theta_i$, then s_i is called *truth-telling*.

DEFINITION 3: A combination of strategies $(s_i^*)_{i=0}^N$ is a *Bayesian Nash equilibrium* for the mechanism Γ if for each $i \in \{0, 1, \dots, N\}$ and each $\theta_i \in \Theta_i$, the following condition is satisfied:

$$(6) \quad \int u_i(f(s_i^*(\theta_i), s_{-i}^*(\theta_{-i}), \theta_i) d\Phi_{-i}(\theta_{-i} | \theta_i) \geq \int u_i(f(\hat{\theta}_i, s_{-i}^*(\theta_{-i}), \theta_i) d\Phi_{-i}(\theta_{-i} | \theta_i)$$

for all $\hat{\theta}_i \in \Theta_i$.

Note that in (6) we have use the following convention: $\theta_{-i} = (\theta_0, \theta_1, \dots, \theta_{-(i-1)}, \theta_{(i+1)}, \dots, \theta_N)$, and $\Phi_{-i}(\theta_{-i})$ is the distribution function of θ_{-i} . Also, $s_{-i} = (s_0, s_1, \dots, s_{-(i-1)}, s_{(i+1)}, \dots, s_N)$ represents the lists of strategies of bureaucrats other than the i th bureaucrat.

3.2.4 The Bayesian Incentive Compatible Constraint and the Interim Individual Rationality Constraints

It is well known that without some appropriate restrictions on f the direct-revelation mechanism $\Gamma = (\Theta_0, \Theta_1, \dots, \Theta_N, f)$ will not work. First, there is no a priori reason to believe that a player will reveal truthfully her type. Under such a scenario, the profile of types, say θ , announced by the players $0, 1, \dots, N$ might not be the true profile of types, and the alternative $f(\theta)$ will not be the alternative the mediator wishes to implement. Second, a player will not participate in the process unless he obtains at least his reservation payoff. In the parlance of mechanism design, the mediator can only successfully implement the social choice function $f(\theta)$ if this function is *Bayesian incentive compatible* and satisfies the *interim rationality constraint* for each of the players.

DEFINITION 4: The social choice function f is *truthfully implementable in Bayesian Nash equilibrium (or Bayesian incentive compatible)* if the combination of strategies $(s_i^*)_{i=0}^N$, where s_i^* is truth telling for each $i \in \{0, 1, \dots, N\}$, is a Bayesian Nash equilibrium for the mechanism $\Gamma = (\Theta_0, \Theta_1, \dots, \Theta_N, f)$.

Now consider a direct revelation mechanism $\Gamma = (\Theta_0, \Theta_1, \dots, \Theta_N, f)$, where

$$f(\theta) = (q_0(\theta), q_1(\theta), \dots, q_N(\theta), b_0(\theta), b_1(\theta), \dots, b_N(\theta))$$

is the alternative implemented when θ is the profile of types of the entrepreneur and the N bureaucrats in the track. Under this mechanism, the payoff of bureaucrat i is given by

$$\begin{aligned}
 (7) \quad u_i(f(\theta), \theta_i) &= \left[-\left(\prod_{j=0}^N q_j(\theta)\right) p \theta_i \right] + \left[\left(\prod_{j=0}^N q_j(\theta)\right) (1-p) b_i(\theta) \right] + \left[[1 - p \left(\prod_{j=0}^N q_j(\theta)\right)] \omega_i \right] \\
 &= -pQ(\theta)\theta_i + (1-p)Q(\theta)b_i(\theta) + [1 - pQ(\theta)]\omega_i,
 \end{aligned}$$

where we have let

$$(8) \quad Q(\theta) = \prod_{j=0}^N q_j(\theta)$$

denote the probability that the entrepreneur applies for the permit and his application is approved by each of the bureaucrats. As for the entrepreneur, his payoff is given by

$$(9) \quad u_0(f(\theta), \theta_0) = (1-p)Q(\theta)[\theta_0 + b_0(\theta)].$$

Under the mechanism Γ , the expected payoff of the i th bureaucrat, given that he announces $\hat{\theta}_i$ as his type and all the other players reveal truthfully their types, is then given by

$$\begin{aligned}
 (10) \quad \int u_i(f(\hat{\theta}_i, \theta_{-i}), \theta_i) d\Phi_{-i}(\theta_{-i}) &= -p \left[\int Q(\hat{\theta}_i, \theta_{-i}) d\Phi_{-i}(\theta_{-i}) \right] \theta_i \\
 &\quad + (1-p) \left[\int Q(\hat{\theta}_i, \theta_{-i}) b_i(\hat{\theta}_i, \theta_{-i}) d\Phi_{-i}(\theta_{-i}) \right] \\
 &\quad + (1-p) \left[\int Q(\hat{\theta}_i, \theta_{-i}) d\Phi_{-i}(\theta_{-i}) \right] \omega_i \\
 &= -p\bar{Q}_i(\hat{\theta}_i)\theta_i + \bar{b}_i(\hat{\theta}_i) + [1 - p\bar{Q}_i(\hat{\theta}_i)]\omega_i,
 \end{aligned}$$

($i = 1, \dots, N$).

In (10), we have let

$$(11) \quad \bar{Q}_i(\hat{\theta}_i) = \int Q(\hat{\theta}_i, \theta_{-i}) d\Phi_{-i}(\theta_{-i}), \quad (i = 0, 1, \dots, N),$$

and

$$(12) \quad \bar{b}_i(\hat{\theta}_i) = (1-p) \int Q(\hat{\theta}_i, \theta_{-i}) b_i(\hat{\theta}_i, \theta_{-i}) d\Phi_{-i}(\theta_{-i}), \quad (i = 1, \dots, N).$$

As defined, $\bar{Q}_i(\hat{\theta}_i)$ represents the probability that the entrepreneur applies for the permit and the application is approved under the mechanism Γ , given that bureaucrat i announces $\hat{\theta}_i$ as his type while all the other players reveal their types truthfully. Also, $\bar{b}_i(\hat{\theta}_i)$ is the expected bribe received by bureaucrat i , given that this bureaucrat announces $\hat{\theta}_i$ as his type while all the other players reveal their types truthfully. If the type of the i th bureaucrat is θ_i , and if all the players reveal their types truthfully, then the expected payoff of this bureaucrat is given by

$$(13) \quad U_i(\theta_i) = -p\bar{Q}_i(\theta_i)\theta_i + \bar{b}_i(\theta_i) + [1 - p\bar{Q}_i(\theta_i)]\omega_i.$$

As for the entrepreneur, his expected payoff, given that he announces $\hat{\theta}_0$ as its type and all the other players reveal truthfully their types, is given by

$$(14) \quad \begin{aligned} & \int u_0(f(\hat{\theta}_0, \theta_{-0}), \theta_0) d\Phi_{-0}(\theta_{-0}) \\ &= (1-p)\bar{Q}_0(\hat{\theta}_0)\theta_0 + (1-p) \int [Q(\hat{\theta}_0, \theta_{-0})b_0(\hat{\theta}_0, \theta_{-0})] d\Phi_{-0}(\theta_{-0}) \\ &= (1-p)\bar{Q}_0(\hat{\theta}_0)\theta_0 + \bar{b}_0(\hat{\theta}_0), \end{aligned}$$

where we have let

$$(15) \quad \bar{Q}_0(\hat{\theta}_0) = \int Q(\hat{\theta}_0, \theta_{-0}) d\Phi_{-0}(\theta_{-0}),$$

and

$$(16) \quad \bar{b}_0(\hat{\theta}_0) = (1-p) \int [Q(\hat{\theta}_0, \theta_{-0})b_0(\hat{\theta}_0, \theta_{-0})] d\Phi_{-0}(\theta_{-0}).$$

As defined, $\bar{Q}_0(\hat{\theta}_0)$ represents the probability that the entrepreneur applies for the permit and the application is approved under the mechanism Γ , given that the entrepreneur announces $\hat{\theta}_0$ as his type while all the other players reveal their types truthfully. Also, $-\bar{b}_0(\hat{\theta}_0)$ is the total expected bribe paid by the entrepreneur, given that he announces $\hat{\theta}_0$ as his type while all the bureaucrats reveal their types truthfully. If the type of the entrepreneur is θ_0 and if all the bureaucrats reveal their types truthfully, then the expected payoff of the entrepreneur is given by

$$(17) \quad U_0(\theta_0) = (1-p)\bar{Q}_0(\theta_0)\theta_0 + \bar{b}_0(\theta_0).$$

PROPOSITION 1: Let $f : \theta \rightarrow f(\theta) = (q_0(\theta), q_1(\theta), \dots, q_N(\theta), b_0(\theta), b_1(\theta), \dots, b_N(\theta))$ be a social choice function. Then f is Bayesian incentive compatible if and only if the following conditions are satisfied:

(a) For each bureaucrat $i \in \{1, \dots, N\}$,

(a.1) $\bar{Q}_i : \theta_i \rightarrow \bar{Q}_i(\theta_i)$ is non-increasing, and

(a.2) $U_i(\theta_i) = U_i(\bar{\theta}_i) + p \int_{\bar{\theta}_i}^{\theta_i} \bar{Q}_i(t) dt$ for all $\theta_i \in \Theta_i$.

(b) For the entrepreneur

(b.1) $\bar{Q}_0 : \theta_0 \rightarrow \bar{Q}_0(\theta_0)$ is non-decreasing, and

(b.2) $U_0(\theta_0) = U_0(\underline{\theta}_0) + (1-p) \int_{\underline{\theta}_0}^{\theta_0} \bar{Q}_0(t) dt$ for all $\theta_0 \in \Theta_0$.

PROOF: To prove the necessary part of the proposition, suppose that the social choice function f is Bayesian incentive compatible. Consider a bureaucrat, say i , and two possible values, say θ_i and $\hat{\theta}_i$, for his type, with $\theta_i < \hat{\theta}_i$. Because truth telling is his best response under the social choice function f , we must have

$$\begin{aligned}
 U_i(\theta_i) &\geq -p\bar{Q}_i(\hat{\theta}_i)\theta_i + \bar{b}_i(\hat{\theta}_i) + [1-p\bar{Q}_i(\hat{\theta}_i)]\omega_i \\
 (18) \quad &= -p\bar{Q}_i(\hat{\theta}_i)\hat{\theta}_i + \bar{b}_i(\hat{\theta}_i) + [1-p\bar{Q}_i(\hat{\theta}_i)]\omega_i + p\bar{Q}_i(\hat{\theta}_i)\hat{\theta}_i - p\bar{Q}_i(\hat{\theta}_i)\theta_i \\
 &= U_i(\hat{\theta}_i) - p\bar{Q}_i(\hat{\theta}_i)[\theta_i - \hat{\theta}_i].
 \end{aligned}$$

In the same manner, we have

$$(19) \quad U_i(\hat{\theta}_i) \geq U_i(\theta_i) - p\bar{Q}_i(\theta_i)[\hat{\theta}_i - \theta_i].$$

It follows directly from (18) and (19) that

$$(20) \quad -p\bar{Q}_i(\theta_i) \leq \frac{U_i(\hat{\theta}_i) - U_i(\theta_i)}{\hat{\theta}_i - \theta_i} \leq -p\bar{Q}_i(\hat{\theta}_i).$$

It follows from the inequality between the first and last expression in (20) that

$$(21) \quad \bar{Q}_i(\theta_i) \geq \bar{Q}_i(\hat{\theta}_i),$$

i.e., $\bar{Q}_i(\theta_i)$ is non-increasing in θ_i , proving (a.1). Next, letting $\hat{\theta}_i \downarrow \theta_i$, we then obtain

$$(22) \quad U_i'(\theta_i) = -p\bar{Q}_i(\theta_i).$$

It follows from (20) that

$$(23) \quad U_i(\theta_i) = U_i(\bar{\theta}_i) + p \int_{\bar{\theta}_i}^{\theta_i} \bar{Q}_i(t) dt,$$

proving (a.2).

To prove (b.1) and (b.2), pick two possible values, say θ_0 and $\hat{\theta}_0$, with $\theta_0 < \hat{\theta}_0$ for the type of the entrepreneur. Because truth telling is the best response of the entrepreneur when all the other players tell the truth about their types, we must have

$$(24) \quad \begin{aligned} U_0(\theta_0) &\geq (1-p)\bar{Q}_0(\hat{\theta}_0)\theta_0 + (1-p) \int [Q(\hat{\theta}_0, \theta_{-0})b_0(\hat{\theta}_0, \theta_{-0})d\Phi_{-0}(\theta_{-0}) \\ &= (1-p)\bar{Q}_0(\hat{\theta}_0)\hat{\theta}_0 - (1-p) \int [Q(\hat{\theta}_0, \theta_{-0})b_0(\hat{\theta}_0, \theta_{-0})d\Phi_{-0}(\theta_{-0}) \\ &\quad + (1-p)\bar{Q}_0(\hat{\theta}_0)[\theta_0 - \hat{\theta}_0] \\ &= U_0(\hat{\theta}_0) + (1-p)\bar{Q}_0(\hat{\theta}_0)[\theta_0 - \hat{\theta}_0]. \end{aligned}$$

In the same manner, we have

$$(25) \quad U_0(\hat{\theta}_0) \geq U_0(\theta_0) + (1-p)\bar{Q}_0(\theta_0)[\hat{\theta}_0 - \theta_0].$$

It then follows directly from (24) and (25) that

$$(26) \quad (1-p)\bar{Q}_0(\theta_0) \leq \frac{U_0(\hat{\theta}_0) - U_0(\theta_0)}{\hat{\theta}_0 - \theta_0} \leq (1-p)\bar{Q}_0(\hat{\theta}_0).$$

The inequality between the first and last expression in (26) shows that $\bar{Q}_0(\theta_0)$ is non-decreasing in θ_0 , proving (b.1). Furthermore, if we let $\hat{\theta}_0 \downarrow \theta_0$, then (24) becomes

$$(27) \quad U_0'(\theta_0) = (1-p)\bar{Q}_0(\theta_0),$$

which can be expressed under the following integral form:

$$(28) \quad U_0(\theta_0) = U_0(\underline{\theta}_0) + (1-p) \int_{\underline{\theta}_0}^{\theta_0} \bar{Q}_0(t) dt,$$

which is (b.2).

To prove the sufficient part of the proposition, suppose that (a.1) and (a.2) hold. Pick a bureaucrat, say i , and suppose that θ_i is his type. Let $\hat{\theta}_i$ be the type he announces.

There are two possibilities to consider: $\hat{\theta}_i > \theta_i$ and $\hat{\theta}_i < \theta_i$. If $\hat{\theta}_i > \theta_i$, then we can write

$$(29) \quad U_i(\hat{\theta}_i) - U_i(\theta_i) = -p \int_{\theta_i}^{\hat{\theta}_i} \bar{Q}_i(t) dt \leq -p \bar{Q}_i(\hat{\theta}_i) [\hat{\theta}_i - \theta_i].$$

Note that in (29) the equality is obtained with the help of (a.2), and the inequality is obtained with the help of (a.1). It follows from (29) that

$$(30) \quad \begin{aligned} U_i(\theta_i) &\geq U_i(\hat{\theta}_i) + p \bar{Q}_i(\hat{\theta}_i) [\hat{\theta}_i - \theta_i] \\ &= -p \bar{Q}_i(\hat{\theta}_i) \hat{\theta}_i + \bar{b}_i(\hat{\theta}_i) + [1 - p \bar{Q}_i(\hat{\theta}_i)] \omega_i + p \bar{Q}_i(\hat{\theta}_i) [\hat{\theta}_i - \theta_i] \\ &= -p \bar{Q}_i(\hat{\theta}_i) \theta_i + \bar{b}_i(\hat{\theta}_i) + [1 - p \bar{Q}_i(\hat{\theta}_i)] \omega_i. \end{aligned}$$

Note that the expression on the last line of (30) represents the expected payoff of the bureaucrat if he overstates his type when all the other players reveal their types truthfully. The inequality between the first and last expressions of (30) indicates that exaggerating one's type does not pay. Next, consider the case $\hat{\theta}_i < \theta_i$. Again, using (a.2), then (a.1), we can write

$$(31) \quad U_i(\theta_i) - U_i(\hat{\theta}_i) = -p \int_{\hat{\theta}_i}^{\theta_i} \bar{Q}_i(t) dt \geq -p \bar{Q}_i(\hat{\theta}_i) [\theta_i - \hat{\theta}_i].$$

We can rewrite (31) as follows:

$$(32) \quad \begin{aligned} U_i(\theta_i) &\geq U_i(\hat{\theta}_i) - p \bar{Q}_i(\hat{\theta}_i) [\theta_i - \hat{\theta}_i] \\ &= -p \bar{Q}_i(\hat{\theta}_i) \hat{\theta}_i + \bar{b}_i(\hat{\theta}_i) + [1 - p \bar{Q}_i(\hat{\theta}_i)] \omega_i - p \bar{Q}_i(\hat{\theta}_i) [\theta_i - \hat{\theta}_i] \\ &= -p \bar{Q}_i(\hat{\theta}_i) \theta_i + \bar{b}_i(\hat{\theta}_i) + [1 - p \bar{Q}_i(\hat{\theta}_i)] \omega_i. \end{aligned}$$

The inequality between the first and last expressions of (32) indicates that understating one's type does not pay, either. We have just shown that the best response of a bureaucrat is to tell the truth if all the other players announce their types truthfully.

Finally, to show that truth telling is also the best response for the entrepreneur if all the bureaucrats tell the truth, suppose that θ_0 is the type of the entrepreneur, and $\hat{\theta}_0$ is his announced type. If $\hat{\theta}_0 > \theta_0$, we can use (b.2) then (b.1) to write

$$(33) \quad U_0(\hat{\theta}_0) - U_0(\theta_0) = (1-p) \int_{\theta_0}^{\hat{\theta}_0} \bar{Q}_0(t) dt \leq (1-p) \bar{Q}_0(\hat{\theta}_0) [\hat{\theta}_0 - \theta_0].$$

We can rewrite (33) as follows:

$$(34) \quad \begin{aligned} U_0(\theta_0) &\geq U_0(\hat{\theta}_0) - (1-p) \bar{Q}_0(\hat{\theta}_0) [\hat{\theta}_0 - \theta_0] \\ &= (1-p) \bar{Q}_0(\hat{\theta}_0) \hat{\theta}_0 + \bar{b}_i(\hat{\theta}_0) - (1-p) \bar{Q}_0(\hat{\theta}_0) [\hat{\theta}_0 - \theta_0] \\ &= (1-p) \bar{Q}_0(\hat{\theta}_0) \theta_0 + \bar{b}_i(\hat{\theta}_0). \end{aligned}$$

The inequality between the left side of the inequality in (34) and the expression on the last line of (34) indicates that it does not pay for the entrepreneur to overstate his type.

On the other hand, if $\hat{\theta}_0 < \theta_0$, then we can use (b.2) then (b.1) to write

$$(35) \quad U_0(\theta_0) - U_0(\hat{\theta}_0) = (1-p) \int_{\hat{\theta}_0}^{\theta_0} \bar{Q}_0(t) dt \geq (1-p) \bar{Q}_0(\hat{\theta}_0) [\theta_0 - \hat{\theta}_0].$$

We can rewrite (35) as follows:

$$(36) \quad \begin{aligned} U_0(\theta_0) &\geq U_0(\hat{\theta}_0) + (1-p) \bar{Q}_0(\hat{\theta}_0) [\theta_0 - \hat{\theta}_0] \\ &= (1-p) \bar{Q}_0(\hat{\theta}_0) \hat{\theta}_0 + \bar{b}_0(\hat{\theta}_0) + (1-p) \bar{Q}_0(\hat{\theta}_0) [\theta_0 - \hat{\theta}_0] \\ &= (1-p) \bar{Q}_0(\hat{\theta}_0) \theta_0 + \bar{b}_0(\hat{\theta}_0). \end{aligned}$$

The inequality between the expression on the left side of the inequality in (36) and the expression on the last line of (36) indicates that understating his type does not make the entrepreneur better-off if all the other players are truthful about their types. ■

Let f be a social choice function, and consider the direct revelation mechanism $\Gamma = (\Theta_0, \Theta_1, \dots, \Theta_N, f)$. Suppose that θ_i is the private information of player $i, i = 0, 1, \dots, N$. Let $\bar{u}_i(\theta_i)$ denote the expected payoff obtained by this player if he refuses to participate in the mechanism Γ . Then we have

$$(37) \quad \bar{u}_0(\theta_0) = 0 \text{ for all } \theta_0 \in \Theta_0,$$

and

$$(38) \quad \bar{u}_i(\theta_i) = \omega_i \text{ for all } \theta_i \in \Theta_i. \quad (i = 1, \dots, N).$$

Next, let

$$(39) \quad U_i(\theta_i | f) = \int u_i(f(\theta_i, \theta_{-i}), \theta_i) d\Phi_{-i}(\theta_{-i}), \quad (i = 0, 1, \dots, N)$$

denote the *interim expected profit* of player i if he participates in the mechanism Γ .

DEFINITION 5: The mechanism $\Gamma = (\Theta_0, \Theta_1, \dots, \Theta_N, f)$ is said to satisfy the *interim individual rationality constraints* if for each $i \in \{0, 1, \dots, N\}$ the following *interim participation constraint* is satisfied: $U_i(\theta_i|f) \geq \bar{u}_i(\theta_i)$ for all $\theta_i \in \Theta_i$.

Let $f : \theta \rightarrow f(\theta) = (q_0(\theta), q_1(\theta), \dots, q_N(\theta), b_0(\theta), b_1(\theta), \dots, b_N(\theta))$ be a social choice function that is Bayesian incentive compatible. If trade does not take place, then no money changes hands. If trade takes place, then the difference between the amount that the entrepreneur pays the N bureaucrats and the sum of the bribes is $-b_0(\theta) - \sum_{i=1}^N b_i(\theta)$. Hence for any profile of types θ , the expected budget under f , namely the expected value of the difference between what the entrepreneur is required to pay and the sum of the bribes received by the track of bureaucrats is given by

$$\begin{aligned} V(f) &= \int (1-p)Q(\theta) \left[-b_0(\theta) - \sum_{i=1}^N b_i(\theta) \right] d\Phi(\theta) \\ (40) \quad &= -\int \bar{b}_0(\theta_0) d\Phi_0(\theta_0) - \sum_{i=1}^N \int \bar{b}_i(\theta_i) d\Phi_i(\theta_i). \end{aligned}$$

Now for each $i = 1, \dots, N$, using (13), we can write the expected bribe received by bureaucrat i as follows:

$$\begin{aligned} \int \bar{b}_i(\theta_i) d\Phi_i(\theta_i) &= \int [U_i(\theta_i) + p\bar{Q}_i(\theta_i)\theta_i - [1-p\bar{Q}_i(\theta_i)]\omega_i] d\Phi_i(\theta_i) \\ (41) \quad &= \int \left[U_i(\bar{\theta}_i) + p \int_{\bar{\theta}_i}^{\bar{\theta}_i} \bar{Q}_i(t) dt + p\bar{Q}_i(\theta_i)\theta_i - [1-p\bar{Q}_i(\theta_i)]\omega_i \right] d\Phi_i(\theta_i) \\ &= U_i(\bar{\theta}_i) + \int [p\bar{Q}_i(\theta_i)\theta_i - [1-p\bar{Q}_i(\theta_i)]\omega_i] d\Phi_i(\theta_i) + \int \left[p \int_{\bar{\theta}_i}^{\bar{\theta}_i} \bar{Q}_i(t) dt \right] d\Phi_i(\theta_i). \end{aligned}$$

Using integration by parts, we can rewrite the integral on the last line of (41) as follows:

$$\begin{aligned} \int \left[p \int_{\bar{\theta}_i}^{\bar{\theta}_i} \bar{Q}_i(t) dt \right] d\Phi_i(\theta_i) &= \int_{\bar{\theta}_i}^{\bar{\theta}_i} \left[p \int_{\bar{\theta}_i}^{\bar{\theta}_i} \bar{Q}_i(t) dt \right] \phi_i(\theta_i) d\theta_i \\ (42) \quad &= \int_{\bar{\theta}_i}^{\bar{\theta}_i} [p\bar{Q}_i(\theta_i)] \Phi_i(\theta_i) d\theta_i. \end{aligned}$$

Using (42) in (41), we obtain the following expression for the expected bribe received by bureaucrat $i, i = 1, \dots, N$,

$$\begin{aligned}
 \int \bar{b}_i(\theta_i) d\Phi_i(\theta_i) &= U_i(\bar{\theta}_i) + \int [p\bar{Q}_i(\theta_i)\theta_i - [1-p\bar{Q}_i(\theta_i)]\omega_i] d\Phi_i(\theta_i) \\
 (43) \quad &+ \int_{\underline{\theta}_i}^{\bar{\theta}_i} [p\bar{Q}_i(\theta_i)] \Phi_i(\theta_i) d\theta_i \\
 &= U_i(\bar{\theta}_i) - \omega_i + \int_{\underline{\theta}_i}^{\bar{\theta}_i} p\bar{Q}_i(\theta_i) \left[\omega_i + \theta_i + \frac{\Phi_i(\theta_i)}{\phi_i(\theta_i)} \right] \phi_i(\theta_i) d\theta_i \\
 &= U_i(\bar{\theta}_i) - \omega_i + \int_{\underline{\theta}_0}^{\bar{\theta}_0} \dots \int_{\underline{\theta}_N}^{\bar{\theta}_N} pQ(\theta) \left[\omega_i + \theta_i + \frac{\Phi_i(\theta_i)}{\phi_i(\theta_i)} \right] \left[\prod_{j=0}^N \phi_j(\theta_j) \right] d\theta_0 \dots d\theta_N.
 \end{aligned}$$

For the entrepreneur, the expected total bribe he offers to the N bureaucrats is

$$\begin{aligned}
 \int [-\bar{b}_0(\theta_0)] d\Phi_0(\theta_0) &= \int [(1-p)\bar{Q}_0(\theta_0)\theta_0 - U_0(\theta_0)] d\Phi_0(\theta_0) \\
 &= \int \left[(1-p)\bar{Q}_0(\theta_0)\theta_0 - U_0(\underline{\theta}_0) - (1-p) \int_{\underline{\theta}_0}^{\theta_0} \bar{Q}_0(t) dt \right] d\Phi_0(\theta_0) \\
 (44) \quad &= -U_0(\underline{\theta}_0) - (1-p) \int_{\underline{\theta}_0}^{\bar{\theta}_0} \int_{\underline{\theta}_0}^{\theta_0} \bar{Q}_0(t) dt - \bar{Q}_0(\theta_0)\theta_0] \phi_0(\theta_0) d\theta_0 \\
 &= -U_0(\underline{\theta}_0) - (1-p) \left(\int_{\underline{\theta}_0}^{\bar{\theta}_0} \int_{\underline{\theta}_0}^{\theta_0} \bar{Q}_0(t) dt] \phi_0(\theta_0) d\theta_0 - \int_{\underline{\theta}_0}^{\bar{\theta}_0} [\bar{Q}_0(\theta_0)\theta_0] \phi_0(\theta_0) d\theta_0 \right).
 \end{aligned}$$

Note that the first line in (44) has been obtained with the help of (17), and the second line with the help of (b.2) of Proposition 1. Now using integration by parts, we can evaluate the first integral on the last line of (44) as follows:

$$\begin{aligned}
 \int_{\underline{\theta}_0}^{\bar{\theta}_0} \int_{\underline{\theta}_0}^{\theta_0} \bar{Q}_0(t) dt] \phi_0(\theta_0) d\theta_0 &= \left[\int_{\underline{\theta}_0}^{\theta_0} \bar{Q}_0(t) dt] \Phi_0(\theta_0) \right]_{\underline{\theta}_0}^{\bar{\theta}_0} - \int_{\underline{\theta}_0}^{\bar{\theta}_0} \bar{Q}_0(\theta_0) \Phi_0(\theta_0) d\theta_0 \\
 (45) \quad &= \int_{\underline{\theta}_0}^{\bar{\theta}_0} \bar{Q}_0(\theta_0) [1 - \Phi_0(\theta_0)] d\theta_0.
 \end{aligned}$$

Using (45) in (44), we obtain

$$\begin{aligned}
& \int [-\bar{b}_0(\theta_0)] d\Phi_0(\theta_0) \\
(46) \quad & = -U_0(\underline{\theta}_0) - (1-p) \left(\int_{\underline{\theta}_0}^{\bar{\theta}_0} \bar{Q}_0(\theta_0) [1 - \Phi_0(\theta_0)] d\theta_0 - \int_{\underline{\theta}_0}^{\bar{\theta}_0} [\bar{Q}_0(\theta_0) \theta_0] \phi_0(\theta_0) d\theta_0 \right) \\
& = -U_0(\underline{\theta}_0) + (1-p) \int_{\underline{\theta}_0}^{\bar{\theta}_0} \bar{Q}_0(\theta_0) \left[\theta_0 - \frac{1 - \Phi_0(\theta_0)}{\phi_0(\theta_0)} \right] \phi_0(\theta_0) d\theta_0.
\end{aligned}$$

Using (43) and (46), we can rewrite (40) as follows:

$$\begin{aligned}
(47) \quad V(f) & = -U_0(\underline{\theta}_0) - \sum_{i=1}^N [U_i(\bar{\theta}_i) - \omega_i] \\
& \quad + \int_{\underline{\theta}_0}^{\bar{\theta}_0} \dots \int_{\underline{\theta}_N}^{\bar{\theta}_N} Q(\theta) \left((1-p) \left[\theta_0 - \frac{1 - \Phi_0(\theta_0)}{\phi_0(\theta_0)} \right] - p \sum_{i=1}^N \left[\omega_i + \theta_i + \frac{\Phi_i(\theta_i)}{\phi_i(\theta_i)} \right] \right) \left[\prod_{j=0}^N \phi_j(\theta_j) \right] d\theta_0 \dots d\theta_N.
\end{aligned}$$

Now observe that if $V(f) = 0$, then the expected budget is balanced under f , and this is one of the conditions for the social-choice function f to be ex post efficient.

Next, note that if the entrepreneur applies for the permit and his application is approved by all the bureaucrats, then the total expected gain— as a function of θ — of all these agents is given by

$$(48) \quad (1-p) \left[\theta_0 + \sum_{i=1}^N \omega_i \right] - p \sum_{i=1}^N \theta_i - \sum_{i=1}^N \omega_i = (1-p)\theta_0 - p \sum_{i=1}^N (\omega_i + \theta_i).$$

For a Bayesian incentive compatible social-choice function f to be ex post efficient (48) must be non-negative, in addition to the requirement that the budget be balanced.

Myerson and Satterthwaite (1983) showed — in a model of bilateral trade in which the buyer and the seller are risk-neutral and their valuations for the object of the trade are private information — that there is no Bayesian incentive compatible social-choice function that is ex post efficient and satisfies the interim individual rationality constraints. This impossibility result also holds in our model that we state formally as follows:

PROPOSITION 2: Suppose that $\underline{\theta}_0 < \frac{p}{1-p} \sum_{i=1}^N (\omega_i + \underline{\theta}_i)$ and $\frac{p}{1-p} \sum_{i=1}^n (\omega_i + \bar{\theta}_i) < \bar{\theta}_0$.

Then there is no social-choice function that is Bayesian incentive compatible; satisfies the interim individual rationality constraints; and is ex post efficient.

PROOF: Note that the first inequality ensures that there is a positive probability that the project will not be carried out, and this event occurs when the value of the project is small. As for the second inequality, it ensures that no matter what the types of the N bureaucrats, there is a positive probability that the project will be carried out if the value of the project is high. We will prove the proposition for the case of $N = 2$ bureaucrats; the proof is by reductio ad absurdum.

Suppose then that there exists a social-choice function f that is Bayesian incentive compatible; satisfies the interim individual rationality constraints; and is ex post efficient. Using the balanced-budget constraint and (47), we can write

$$\begin{aligned}
 (49) \quad & \int_{\underline{\theta}_0}^{\bar{\theta}_0} \dots \int_{\underline{\theta}_N}^{\bar{\theta}_N} Q(\theta) \left((1-p) \left[\theta_0 - \frac{1 - \Phi_0(\theta_0)}{\phi_0(\theta_0)} \right] - p \sum_{i=1}^N \left[\omega_i + \theta_i + \frac{\Phi_i(\theta_i)}{\phi_i(\theta_i)} \right] \right) \left[\prod_{j=0}^N \phi_j(\theta_j) \right] d\theta_0 \dots d\theta_N \\
 & = U_0(\underline{\theta}_0) + \sum_{i=1}^N [U_i(\bar{\theta}_i) - \omega_i] \geq 0.
 \end{aligned}$$

Note that the inequality in (49) has been obtained by using the interim individual rationality constraints: $U_0(\underline{\theta}_0) \geq 0$, and $U_i(\bar{\theta}_i) - \omega_i \geq 0, i = 1, \dots, N$. Furthermore, because f is ex post efficient, we must have $Q(\theta) = 1$ when (48) is non-negative, and $Q(\theta) = 0$ when (48) is negative, and these results allow us to rewrite the multiple integral in (49) as follows

(50)

$$\begin{aligned}
& \int_{\underline{\theta}_0}^{\bar{\theta}_0} \dots \int_{\underline{\theta}_N}^{\bar{\theta}_N} \mathcal{Q}(\theta) \left((1-p) \left[\theta_0 - \frac{1 - \Phi_0(\theta_0)}{\phi_0(\theta_0)} \right] \right. \\
& \quad \left. - p \sum_{i=1}^N \left[\omega_i + \theta_i + \frac{\Phi_i(\theta_i)}{\phi_i(\theta_i)} \right] \right) \left[\prod_{j=0}^N \phi_j(\theta_j) \right] d\theta_0 \dots d\theta_N \\
&= \int_{\underline{\theta}_N}^{\bar{\theta}_N} \dots \int_{\underline{\theta}_1}^{\bar{\theta}_1} \int_{\frac{p \sum_{i=1}^N (\omega_i + \theta_i)}{1-p}}^{\bar{\theta}_0} \left((1-p) \left[\theta_0 \phi_0(\theta_0) - 1 + \Phi_0(\theta_0) \right] \right. \\
& \quad \left. - p \phi_0(\theta_0) \sum_{i=1}^N \left[\omega_i + \theta_i + \frac{\Phi_i(\theta_i)}{\phi_i(\theta_i)} \right] \right) d\theta_0 \left[\prod_{j=1}^N \phi_j(\theta_j) \right] d\theta_1 \dots d\theta_N.
\end{aligned}$$

Now

$$\begin{aligned}
& \int_{\frac{p \sum_{i=1}^N (\omega_i + \theta_i)}{1-p}}^{\bar{\theta}_0} \left((1-p) \left[\theta_0 \phi_0(\theta_0) - 1 + \Phi_0(\theta_0) \right] \right. \\
& \quad \left. - p \phi_0(\theta_0) \sum_{i=1}^N \left[\omega_i + \theta_i + \frac{\Phi_i(\theta_i)}{\phi_i(\theta_i)} \right] \right) d\theta_0 \\
&= \int_{\frac{p \sum_{i=1}^N (\omega_i + \theta_i)}{1-p}}^{\bar{\theta}_0} (1-p) [\theta_0 \phi_0(\theta_0) - 1 + \Phi_0(\theta_0)] d\theta_0 \\
& \quad - \int_{\frac{p \sum_{i=1}^N (\omega_i + \theta_i)}{1-p}}^{\bar{\theta}_0} p \phi_0(\theta_0) \sum_{i=1}^N \left[\omega_i + \theta_i + \frac{\Phi_i(\theta_i)}{\phi_i(\theta_i)} \right] d\theta_0 \\
&= I - J,
\end{aligned} \tag{51}$$

where I and J are defined as follows:

$$\begin{aligned}
\frac{I}{1-p} &= \int_{\frac{p \sum_{i=1}^N (\omega_i + \theta_i)}{1-p}}^{\bar{\theta}_0} [\theta_0 \phi_0(\theta_0) - 1 + \Phi_0(\theta_0)] d\theta_0 \\
&= [\theta_0 \Phi_0(\theta_0)]_{\frac{p \sum_{i=1}^N (\omega_i + \theta_i)}{1-p}}^{\bar{\theta}_0} - \int_{\frac{p \sum_{i=1}^N (\omega_i + \theta_i)}{1-p}}^{\bar{\theta}_0} \Phi_0(\theta_0) d\theta_0 - [\theta_0]_{\frac{p \sum_{i=1}^N (\omega_i + \theta_i)}{1-p}}^{\bar{\theta}_0} + \int_{\frac{p \sum_{i=1}^N (\omega_i + \theta_i)}{1-p}}^{\bar{\theta}_0} \Phi_0(\theta_0) d\theta_0 \\
&= [\theta_0 \Phi_0(\theta_0)]_{\frac{p \sum_{i=1}^N (\omega_i + \theta_i)}{1-p}}^{\bar{\theta}_0} - [\theta_0]_{\frac{p \sum_{i=1}^N (\omega_i + \theta_i)}{1-p}}^{\bar{\theta}_0} \\
&= \left[\bar{\theta}_0 - \frac{p \sum_{i=1}^N (\omega_i + \theta_i)}{1-p} \Phi_0 \left(\frac{p \sum_{i=1}^N (\omega_i + \theta_i)}{1-p} \right) \right] - \left[\bar{\theta}_0 - \frac{p \sum_{i=1}^N (\omega_i + \theta_i)}{1-p} \right] \\
&= \frac{p \sum_{i=1}^N (\omega_i + \theta_i)}{1-p} \left[1 - \Phi_0 \left(\frac{p \sum_{i=1}^N (\omega_i + \theta_i)}{1-p} \right) \right],
\end{aligned} \tag{52}$$

and

$$\begin{aligned}
J &= \int_{\frac{p \sum_{i=1}^N (\omega_i + \theta_i)}{1-p}}^{\bar{\theta}_0} p \phi_0(\theta_0) \sum_{i=1}^N \left[\omega_i + \theta_i + \frac{\Phi_i(\theta_i)}{\phi_i(\theta_i)} \right] d\theta_0 \\
&= \left[p \Phi_0(\theta_0) \sum_{i=1}^N \left[\omega_i + \theta_i + \frac{\Phi_i(\theta_i)}{\phi_i(\theta_i)} \right] \right]_{\frac{p \sum_{i=1}^N (\omega_i + \theta_i)}{1-p}}^{\bar{\theta}_0} \\
&= p \sum_{i=1}^N \left[\omega_i + \theta_i + \frac{\Phi_i(\theta_i)}{\phi_i(\theta_i)} \right] - p \Phi_0 \left(\frac{p \sum_{i=1}^N (\omega_i + \theta_i)}{1-p} \right) \sum_{i=1}^N \left[\omega_i + \theta_i + \frac{\Phi_i(\theta_i)}{\phi_i(\theta_i)} \right] \\
&= p \sum_{i=1}^N \left[\omega_i + \theta_i + \frac{\Phi_i(\theta_i)}{\phi_i(\theta_i)} \right] \left[1 - \Phi_0 \left(\frac{p \sum_{i=1}^N (\omega_i + \theta_i)}{1-p} \right) \right].
\end{aligned} \tag{53}$$

Using (52) and (53) in (51), we obtain

$$\begin{aligned}
& \frac{\int_{\frac{p \sum_{i=1}^N (\omega_i + \theta_i)}{1-p}}^{\bar{\theta}_0} \left((1-p) [\theta_0 \phi_0(\theta_0) - 1 + \Phi_0(\theta_0)] - p \phi_0(\theta_0) \sum_{i=1}^N \left[\omega_i + \theta_i + \frac{\Phi_i(\theta_i)}{\phi_i(\theta_i)} \right] \right) d\theta_0}{1-p} \\
&= p \sum_{i=1}^N (\omega_i + \theta_i) \left[1 - \Phi_0 \left(\frac{p \sum_{i=1}^N (\omega_i + \theta_i)}{1-p} \right) \right] \\
&\quad - p \sum_{i=1}^N \left[\omega_i + \theta_i + \frac{\Phi_i(\theta_i)}{\phi_i(\theta_i)} \right] \left[1 - \Phi_0 \left(\frac{p \sum_{i=1}^N (\omega_i + \theta_i)}{1-p} \right) \right] \\
&= -p \sum_{i=1}^N \left[\frac{\Phi_i(\theta_i)}{\phi_i(\theta_i)} \right] \left[1 - \Phi_0 \left(\frac{p \sum_{i=1}^N (\omega_i + \theta_i)}{1-p} \right) \right] < 0.
\end{aligned}
\tag{54}$$

Using (54), we can rewrite (50) as follows

$$\begin{aligned}
& \int_{\underline{\theta}_0}^{\bar{\theta}_0} \dots \int_{\underline{\theta}_N}^{\bar{\theta}_N} Q(\theta) \left((1-p) \left[\theta_0 - \frac{1 - \Phi_0(\theta_0)}{\phi_0(\theta_0)} \right] - p \sum_{i=1}^N \left[\omega_i + \theta_i + \frac{\Phi_i(\theta_i)}{\phi_i(\theta_i)} \right] \right) \left[\prod_{j=0}^N \phi_j(\theta_j) \right] d\theta_0 \dots d\theta_N \\
&= \int_{\underline{\theta}_N}^{\bar{\theta}_N} \dots \int_{\underline{\theta}_1}^{\bar{\theta}_1} \left[-p \sum_{i=1}^N \left[\frac{\Phi_i(\theta_i)}{\phi_i(\theta_i)} \right] \left[1 - \Phi_0 \left(\frac{p \sum_{i=1}^N (\omega_i + \theta_i)}{1-p} \right) \right] \right] \left[\prod_{j=1}^N \phi_j(\theta_j) \right] d\theta_1 \dots d\theta_N < 0.
\end{aligned}
\tag{55}$$

Clearly, (55) contradicts (49). ■

3.3 THE MECHANISM THAT MAXIMIZES EXPECTED TOTAL GAINS FROM TRADE

According to Proposition 2, ex post efficiency is unattainable. Hence it is natural to search for a mechanism that maximizes the expected total gains from trade subject to the incentive compatible constraint, the interim individual rationality constraints, and the balanced budget constraint. Following the technique developed by Myerson and

Satterthwaite, op cit., for a bilateral trading model, we now find the second-best mechanism for the model of corruption; the argument proceeds in several stages.

3.3.1 *The Probability that the Entrepreneur Applies for the Permit and his Application is Approved by All the Bureaucrats in the Track*

First, we find a function $\theta \rightarrow Q(\theta), \theta \in \Theta$, where $Q(\theta)$ is the probability that the entrepreneur applies for the permit and his application is approved by every bureaucrat in the track, to solve the expected total gains from trade

$$(56) \quad \max_{Q(\theta)} \int \left[(1-p)\theta_0 - p \sum_{i=1}^N (\omega_i + \theta_i) \right] Q(\theta) d\theta$$

subject to the following constraint³⁰

(57)

$$\int_{\underline{\theta}_0}^{\bar{\theta}_0} \dots \int_{\underline{\theta}_N}^{\bar{\theta}_N} Q(\theta) \left((1-p) \left[\theta_0 - \frac{1 - \Phi_0(\theta_0)}{\phi_0(\theta_0)} \right] - p \sum_{i=1}^N \left[\theta_i + \omega_i + \frac{\Phi_i(\theta_i)}{\phi_i(\theta_i)} \right] \right) \left[\prod_{j=0}^N \phi_j(\theta_j) \right] d\theta_0 \dots d\theta_N \geq 0.$$

To solve the preceding maximization problem, define for each $\alpha, 0 \leq \alpha \leq 1$, the following functions:

$$(58) \quad c_0(\theta_0, \alpha) = (1-p) \left[\theta_0 - \alpha \frac{1 - \Phi_0(\theta_0)}{\phi_0(\theta_0)} \right],$$

and

$$(59) \quad c_i(\theta_i, \alpha) = p \left[\omega_i + \theta_i + \alpha \frac{\Phi_i(\theta_i)}{\phi_i(\theta_i)} \right], \quad (i = 1, \dots, N).$$

Next, define

$$(60) \quad \Theta(\alpha) = \left\{ \theta \in \Theta \mid c_0(\theta_0, \alpha) \geq \sum_{i=1}^N c_i(\theta_i, \alpha) \right\},$$

then let

$$(61) \quad \begin{aligned} Q(\theta | \alpha) &= 1 \text{ if } \theta \in \Theta(\alpha), \\ &= 0 \text{ otherwise.} \end{aligned}$$

³⁰ The constraint will be shown to be binding for the solution of this maximization problem, and the integral in (57) will be shown to be the expected budget generated by the optimal solution.

Because $c_0(\theta_0, \alpha) - \sum_{i=1}^N c_i(\theta_i, \alpha)$ is decreasing in α , for any given θ , the probability of trade $Q(\theta|\alpha)$ is also decreasing in α . Next, observe that $Q(\theta|0)$ is the ex post efficient probability that trade takes place between the entrepreneur and the track of bureaucrats, i.e., the entrepreneur applies for the permit, and his application is approved by all the bureaucrats in the track whenever $(1-p)\theta_0 - p\sum_{i=1}^N (\omega_i + \theta_i) \geq 0$. As for $Q(\theta|1)$, it maximizes the integral in (47).

Now consider the following function of α :

$$(62) \quad G(\alpha) = \int_{\underline{\theta}_0}^{\bar{\theta}_0} \dots \int_{\underline{\theta}_N}^{\bar{\theta}_N} Q(\theta|\alpha) \left((1-p) \left[\theta_0 - \frac{1-\Phi_0(\theta_0)}{\phi_0(\theta_0)} \right] - p \sum_{i=1}^N \left[\omega_i + \theta_i + \frac{\Phi_i(\theta_i)}{\phi_i(\theta_i)} \right] \right) \left[\prod_{j=0}^N \phi_j(\theta_j) \right] d\theta_0 \dots d\theta_N.$$

We claim that $G(\alpha)$ is increasing in α . To establish this result, write

$$(63) \quad G(\alpha) = \int_{\theta \in \Theta(\alpha)} Q(\theta|\alpha) \left((1-p) \left[\theta_0 - \frac{1-\Phi_0(\theta_0)}{\phi_0(\theta_0)} \right] - p \sum_{i=1}^N \left[\omega_i + \theta_i + \frac{\Phi_i(\theta_i)}{\phi_i(\theta_i)} \right] \right) \left[\prod_{j=0}^N \phi_j(\theta_j) \right] d\theta_0 \dots d\theta_N$$

$$= \int_{\theta \in \Theta(1)} \left((1-p) \left[\theta_0 - \frac{1-\Phi_0(\theta_0)}{\phi_0(\theta_0)} \right] - p \sum_{i=1}^N \left[\omega_i + \theta_i + \frac{\Phi_i(\theta_i)}{\phi_i(\theta_i)} \right] \right) \left[\prod_{j=0}^N \phi_j(\theta_j) \right] d\theta_0 \dots d\theta_N$$

$$+ \int_{\theta \in [\Theta(\alpha) - \Theta(1)]} \left((1-p) \left[\theta_0 - \frac{1-\Phi_0(\theta_0)}{\phi_0(\theta_0)} \right] - p \sum_{i=1}^N \left[\omega_i + \theta_i + \frac{\Phi_i(\theta_i)}{\phi_i(\theta_i)} \right] \right) \left[\prod_{j=0}^N \phi_j(\theta_j) \right] d\theta_0 \dots d\theta_N.$$

Note that the expression under the integral sign on the last line of (63) is negative. Furthermore, the set $\Theta(\alpha)$ shrinks as α rises. Hence $G(\alpha)$ is an increasing function of α .

Also, we claim that $G(\alpha)$ is a continuous function of α . Indeed, if $\alpha' < \alpha$, then $\Theta(\alpha') \subset \Theta(\alpha)$, and

$$(64) \quad G(\alpha') - G(\alpha) = \int_{\theta \in \Theta(\alpha') - \Theta(\alpha)} \left((1-p) \left[\theta_0 - \frac{1 - \Phi_0(\theta_0)}{\phi_0(\theta_0)} \right] - p \sum_{i=1}^N \left[\omega_i + \theta_i + \frac{\Phi_i(\theta_i)}{\phi_i(\theta_i)} \right] \right) \left[\prod_{j=0}^N \phi_j(\theta_j) \right] d\theta_0 \dots d\theta_N.$$

Furthermore, when $\alpha' \uparrow \alpha$, the set difference $\Theta(\alpha') - \Theta(\alpha)$ shrinks to the empty set, and this implies that $G(\alpha') - G(\alpha)$ tends to 0 as $\alpha' \uparrow \alpha$. In the same manner, we can show that $G(\alpha') - G(\alpha)$ tends to 0 as $\alpha' \downarrow \alpha$.

Because $Q(\theta|1) > 0$ only when $c_0(\theta_0, 1) - \sum_{i=1}^N c_i(\theta_i, 1) \geq 0$, we must have $G(1) \geq 0$. Also, according to (55), we have $G(0) < 0$. Hence by continuity there exists a value of α , say $\alpha = \alpha^*$, $0 < \alpha^* \leq 1$, such that

$$(65) \quad G(\alpha^*) = \int_{\underline{\theta}_0}^{\bar{\theta}_0} \dots \int_{\underline{\theta}_N}^{\bar{\theta}_N} Q(\theta|\alpha^*) \left((1-p) \left[\theta_0 - \frac{1 - \Phi_0(\theta_0)}{\phi_0(\theta_0)} \right] - p \sum_{i=1}^N \left[\omega_i + \theta_i + \frac{\Phi_i(\theta_i)}{\phi_i(\theta_i)} \right] \right) \left[\prod_{j=0}^N \phi_j(\theta_j) \right] d\theta_0 \dots d\theta_N = 0.$$

Because $G(\alpha)$ is increasing in α , the value of α^* is unique.

We now show that $\theta \rightarrow Q(\theta|\alpha^*)$ is the solution of the maximization problem constituted by (56) and (57). To this end, let λ^* be such that $\lambda^*/(1+\lambda^*) = \alpha^*$. Next, consider an arbitrary function $\theta \rightarrow Q(\theta)$ that satisfies the constraint (57). We have

$$(66) \quad \int \left[(1-p)\theta_0 - p \sum_{i=1}^N (\omega_i + \theta_i) \right] p(\theta) d\theta \leq \int \left[(1-p)\theta_0 - p \sum_{i=1}^N (\omega_i + \theta_i) \right] p(\theta) d\theta \\ + \lambda^* \int_{\underline{\theta}_0}^{\bar{\theta}_0} \dots \int_{\underline{\theta}_N}^{\bar{\theta}_N} Q(\theta) \left((1-p) \left[\theta_0 - \frac{1 - \Phi_0(\theta_0)}{\phi_0(\theta_0)} \right] - p \sum_{i=1}^N \left[\theta_i + \omega_i + \frac{\Phi_i(\theta_i)}{\phi_i(\theta_i)} \right] \right) \left[\prod_{j=0}^N \phi_j(\theta_j) \right] d\theta_0 \dots d\theta_N$$

$$\begin{aligned}
&= \int_{\underline{\theta}_0}^{\bar{\theta}_0} \dots \int_{\underline{\theta}_N}^{\bar{\theta}_N} Q(\theta) \left(\begin{aligned} &(1-p) \left[(1+\lambda^*)\theta_0 - \lambda^* \frac{1-\Phi_0(\theta_0)}{\phi_0(\theta_0)} \right] \\ &- p \sum_{i=1}^N \left[(1+\lambda^*)(\theta_i + \omega_i) + \lambda^* \frac{\Phi_i(\theta_i)}{\phi_i(\theta_i)} \right] \end{aligned} \right) \left[\prod_{j=0}^N \phi_j(\theta_j) \right] d\theta_0 \dots d\theta_N \\
&= (1+\lambda^*) \int_{\underline{\theta}_0}^{\bar{\theta}_0} \dots \int_{\underline{\theta}_N}^{\bar{\theta}_N} Q(\theta) \left(\begin{aligned} &(1-p) \left[\theta_0 - \alpha^* \frac{1-\Phi_0(\theta_0)}{\phi_0(\theta_0)} \right] \\ &- p \sum_{i=1}^N \left[(\theta_i + \omega_i) + \alpha^* \frac{\Phi_i(\theta_i)}{\phi_i(\theta_i)} \right] \end{aligned} \right) \left[\prod_{j=0}^N \phi_j(\theta_j) \right] d\theta_0 \dots d\theta_N \\
&= (1+\lambda^*) \int_{\underline{\theta}_0}^{\bar{\theta}_0} \dots \int_{\underline{\theta}_N}^{\bar{\theta}_N} Q(\theta) \left(c_0(\theta_0, \alpha^*) - \sum_{i=1}^N [c_i(\theta_i, \alpha^*)] \right) \left[\prod_{j=0}^N \phi_j(\theta_j) \right] d\theta_0 \dots d\theta_N.
\end{aligned}$$

When $\theta \rightarrow Q(\theta | \alpha^*)$ is used as a candidate to solve the maximization problem constituted by (56) and (57), it yields the following value for the objective function:

$$\begin{aligned}
&\int [(1-p)\theta_0 - p \sum_{i=1}^N (\omega_i + \theta_i)] p(\theta | \hat{\alpha}) d\theta \\
&= \int [(1-p)\theta_0 - p \sum_{i=1}^N (\omega_i + \theta_i)] p(\theta | \hat{\alpha}) d\theta \\
(67) \quad &+ \lambda^* \int_{\underline{\theta}_0}^{\bar{\theta}_0} \dots \int_{\underline{\theta}_N}^{\bar{\theta}_N} Q(\theta | \alpha^*) \left(\begin{aligned} &(1-p) \left[\theta_0 - \frac{1-\Phi_0(\theta_0)}{\phi_0(\theta_0)} \right] \\ &- p \sum_{i=1}^N \left[\theta_i + \omega_i + \frac{\Phi_i(\theta_i)}{\phi_i(\theta_i)} \right] \end{aligned} \right) \left[\prod_{j=0}^N \phi_j(\theta_j) \right] d\theta_0 \dots d\theta_N \\
&= (1+\lambda^*) \int_{\underline{\theta}_0}^{\bar{\theta}_0} \dots \int_{\underline{\theta}_N}^{\bar{\theta}_N} Q(\theta | \hat{\alpha}) \left(c_0(\theta_0, \alpha^*) - \sum_{i=1}^N [c_i(\theta_i, \alpha^*)] \right) \left[\prod_{j=0}^N \phi_j(\theta_j) \right] d\theta_0 \dots d\theta_N.
\end{aligned}$$

Because $Q(\theta | \alpha^*)$ is equal to 1 when $c_0(\theta_0, \alpha^*) - \sum_{i=1}^N c_i(\theta_i, \alpha^*) \geq 0$, and is equal to 0 otherwise, the last line of (67) must be at least equal to the last line of (66), showing that $\theta \rightarrow Q(\theta | \alpha^*)$ is the solution of the maximization problem constituted by (56) and (57).

3.3.2 The Second-Best Mechanism with Expected Balanced Budget Constraint

To find a second-best mechanism which satisfies the expected balanced budget constraint, we need to set up some preliminary machinery.

For any profile of types $\theta \in \Theta$, let the transfer to the entrepreneur be defined by

$$(68) \quad b_0^*(\theta) = \begin{cases} 0 & \text{if } Q(\theta | \alpha^*) = 0, \\ -\min\{t_0 \in \Theta_0 | Q(t_0, \theta_{-0} | \alpha^*) = 1\} & \text{if } Q(\theta | \alpha^*) = 1. \end{cases}$$

Next, note that for a bureaucrat, say i , with type θ_i , the bribe offered him must be at least $p(\omega_i + \theta_i)/(1-p)$ to make him corrupt. Thus, we define the transfer to bureaucrat $i, i = 1, \dots, N$, as follows:

$$(69) \quad b_i^*(\theta) = \begin{cases} 0 & \text{if } Q(\theta | \alpha^*) = 0, \\ \max\left\{\frac{p}{1-p}(\omega_i + t_i) | t_i \in \Theta_i, Q(t_i, \theta_{-i} | \alpha^*) = 1\right\} & \text{if } Q(\theta | \alpha^*) = 1. \end{cases}$$

($i = 1, \dots, N$).

Note that when $Q(\theta | \alpha^*) = 1$, we have $b_0^*(\theta) \leq \theta_0$. Furthermore, when $Q(\theta_0, \theta_{-0} | \alpha^*) = 1$, we have $b_0^*(\theta_0, \theta_{-0}) = \theta_0$. Also, when $Q(\theta | \alpha^*) = 1$, we have $b_i^*(\theta) \geq p(\omega_i + \theta_i)/(1-p)$. Furthermore, we have $b_i^*(\bar{\theta}_i, \theta_{-i}) = p(\omega_i + \bar{\theta}_i)/(1-p)$, when $Q(\bar{\theta}_i, \theta_{-i} | \alpha^*) = 1$.

Now consider the following *modified second-price sealed-bid auction*. The arbitrator asks each agent – entrepreneur as well as bureaucrats – to reveal his type. If θ is the announced profile of types, then the arbitrator will allow trade to take place with probability $Q(\theta | \alpha^*)$. When $Q(\theta | \alpha^*) = 0$, trade does not take place, and no money will change hands. When $Q(\theta | \alpha^*) = 1$, the entrepreneur will only be asked to pay a

total bribe of $-b_0^*(\theta)$ for the permit and bureaucrat i will receive the bribe $b_i^*(\theta)$. We make the following claims:

CLAIM 1: Revealing truthfully his type is a weakly dominant strategy for the entrepreneur and gives this agent a non-negative net payoff.

PROOF: Let θ_0 be the real type of the entrepreneur. If the entrepreneur reveals his type truthfully, then his payoff can be computed as follows. Let $(\tilde{\theta}_1, \dots, \tilde{\theta}_N)$ be the announced profile of types of the bureaucrats. If $Q(\theta_0, \tilde{\theta}_1, \dots, \tilde{\theta}_N | \alpha^*) = 0$, then his payoff will be 0 because trade does not occur. On the other hand, if $Q(\theta_0, \tilde{\theta}_1, \dots, \tilde{\theta}_N | \alpha^*) = 1$, then his payoff will be $\theta_0 + b_0^*(\theta_0, \tilde{\theta}_1, \dots, \tilde{\theta}_N) \geq 0$. Thus revealing his type truthfully will yield the entrepreneur a non-negative net payoff, regardless of the announced profile of types, and this means that for the entrepreneur truth telling satisfies the interim rationality constraint.

To show that truth telling is weakly dominant for the entrepreneur, suppose that he understates his type by announcing his type to be $\theta'_0 < \theta_0$. If $Q(\theta_0, \tilde{\theta}_1, \dots, \tilde{\theta}_N | \alpha^*) = 0$, then we still have $Q(\theta'_0, \tilde{\theta}_1, \dots, \tilde{\theta}_N | \alpha^*) = 0$ and trade still does not take place: understating his type does not improve his payoff under this scenario. If $Q(\theta_0, \tilde{\theta}_1, \dots, \tilde{\theta}_N | \alpha^*) = 1$, then as long as the understatement is not substantial, we still have $Q(\theta'_0, \tilde{\theta}_1, \dots, \tilde{\theta}_N | \alpha^*) = 1$, and the transfer is still given by $b_0^*(\theta_0, \tilde{\theta}_1, \dots, \tilde{\theta}_N)$, yielding the same net payoff $\theta_0 + b_0^*(\theta_0, \tilde{\theta}_1, \dots, \tilde{\theta}_N) \geq 0$ that he can obtain by telling the truth. On the other hand, if the understatement is substantial, we will have $Q(\theta'_0, \tilde{\theta}_1, \dots, \tilde{\theta}_N | \alpha^*) = 0$, which implies that trade will not take place, with the ensuing zero net payoff for the entrepreneur. We have just shown that relative to truth telling, understating his type does not improve the net payoff for the entrepreneur.

Could the entrepreneur improve his net payoff by overstating his type? To answer this question, suppose that he announce a type $\theta'_0 > \theta_0$. Consider first the scenario $Q(\theta_0, \tilde{\theta}_1, \dots, \tilde{\theta}_N | \alpha^*) = 0$. If the overstatement is not substantial, then we still have $Q(\theta'_0, \tilde{\theta}_1, \dots, \tilde{\theta}_N | \alpha^*) = 0$ and trade still does not take place: overstating his type does not improve his payoff under this scenario. On the other hand, if the overstatement is excessive, we will have $Q(\theta'_0, \tilde{\theta}_1, \dots, \tilde{\theta}_N | \alpha^*) = 1$ and trade will take place. However, in this case, the transfer to the entrepreneur will be $b_0^*(\theta_0, \tilde{\theta}_1, \dots, \tilde{\theta}_N)$ – with $\theta_0 < -b_0^*(\theta_0, \tilde{\theta}_1, \dots, \tilde{\theta}_N)$, according to (68) – yielding the entrepreneur a net payoff of $\theta_0 + b_0^*(\theta_0, \tilde{\theta}_1, \dots, \tilde{\theta}_N) < 0$. Next, consider the scenario $Q(\theta_0, \tilde{\theta}_1, \dots, \tilde{\theta}_N | \alpha^*) = 1$. Under this scenario, trade will take place if the entrepreneur tells the truth, and continues to take place if the entrepreneur overstates his type. Therefore, relative to truth telling, overstating does not improve the net payoff of the entrepreneur. ■

CLAIM 2: *Revealing truthfully his type is a weakly dominant strategy for each bureaucrat and yields a payoff of at least ω_i .*

PROOF: Consider a bureaucrat, say i , whose type is θ_i . If the bureaucrat reveals his type truthfully, then his payoff can be computed as follows. Let $(\tilde{\theta}_j)_{j=0, j \neq i}^N$ be the announced profile of types of the other agents. If $Q(\theta_i, (\tilde{\theta}_j)_{j=0, j \neq i}^N | \alpha^*) = 0$, then his payoff will be ω_i because trade does not occur. On the other hand, if $Q(\theta_i, (\tilde{\theta}_j)_{j=0, j \neq i}^N | \alpha^*) = 1$, then the transfer that he receives will be $b_i^*(\theta_i, (\tilde{\theta}_j)_{j=0, j \neq i}^N)$, which, according to (69), satisfies the following inequality:

$$-p\theta_i + (1-p)(\omega_i + b_i^*(\theta_i, (\tilde{\theta}_j)_{j=0, j \neq i}^N)) > \omega_i.$$

To show that truth telling is weakly dominant for the bureaucrat, suppose that he overstates his type by announcing his type to be $\theta'_i > \theta_i$. If $Q(\theta_i, (\tilde{\theta}_j)_{j=0, j \neq i}^N | \alpha^*) = 0$,

then we still have $Q(\theta'_i, (\tilde{\theta}_j)_{j=0, j \neq i}^N | \alpha^*) = 0$, and trade still does not take place: overstating his type does not improve his payoff under this scenario. If $Q(\theta_i, (\tilde{\theta}_j)_{j=0, j \neq i}^N | \alpha^*) = 1$, then as long as the overstatement is not substantial, we still have $Q(\theta'_i, (\tilde{\theta}_j)_{j=0, j \neq i}^N | \alpha^*) = 1$ and the transfer is still given by $b_i^*(\theta_i, (\tilde{\theta}_j)_{j=0, j \neq i}^N)$, yielding the same net payoff $-p\theta_i + (1-p)(\omega_i + b_i^*(\theta_i, (\tilde{\theta}_j)_{j=0, j \neq i}^N)) \geq \omega_i$ that he can obtain by telling the truth. On the other hand, if the overstatement is substantial, we will have $Q(\theta'_i, (\tilde{\theta}_j)_{j=0, j \neq i}^N | \alpha^*) = 0$, which implies that trade will not take place, with the ensuing net payoff of ω_i for the bureaucrat. We have just shown that relative to truth telling, overstating his type does not improve the net payoff for the bureaucrat.

Could the bureaucrat improve his net payoff by understating his type? To answer this question, suppose that he announces a type $\theta'_i < \theta_i$. Under the scenario $Q(\theta_i, (\tilde{\theta}_j)_{j=0, j \neq i}^N | \alpha^*) = 0$, if the understatement is not substantial, then we still have $Q(\theta'_i, (\tilde{\theta}_j)_{j=0, j \neq i}^N | \alpha^*) = 0$ and trade still does not take place: understating his type does not improve the bureaucrat's payoff under this scenario. On the other hand, if the understatement is substantial, then we will have $Q(\theta'_i, (\tilde{\theta}_j)_{j=0, j \neq i}^N | \alpha^*) = 1$ and trade will take place. However, in this case, the transfer to the bureaucrat will be $b_i^*(\theta'_i, (\tilde{\theta}_j)_{j=0, j \neq i}^N)$ which satisfies $-p\theta'_i + (1-p)(\omega_i + b_i^*(\theta'_i, (\tilde{\theta}_j)_{j=0, j \neq i}^N)) = \omega_i$. His net payoff of is then given by

$$-p\theta'_i + (1-p)(\omega_i + b_i^*(\theta'_i, (\tilde{\theta}_j)_{j=0, j \neq i}^N)) < -p\theta_i + (1-p)(\omega_i + b_i^*(\theta_i, (\tilde{\theta}_j)_{j=0, j \neq i}^N)) = \omega_i.$$

Thus, relative to truth telling, understating his type does not improve the net payoff of the bureaucrat, either. ■

The mechanism just described is truthfully implementable in dominant strategies, and satisfies the interim individual rationality constraints. Furthermore, the expected

payments by the entrepreneur minus the expected total bribes under this mechanism is given by

$$\begin{aligned}
(70) \quad & -U_0^*(\underline{\theta}_0) - \sum_{i=1}^N [U_i^*(\bar{\theta}_i) - \omega_i] \\
& + \int_{\underline{\theta}_0}^{\bar{\theta}_0} \dots \int_{\underline{\theta}_N}^{\bar{\theta}_N} Q(\theta | \alpha^*) \left(\begin{aligned} & (1-p) \left[\theta_0 - \frac{1 - \Phi_0(\theta_0)}{\phi_0(\theta_0)} \right] \\ & - p \sum_{i=1}^N \left[\omega_i + \theta_i + \frac{\Phi_i(\theta_i)}{\phi_i(\theta_i)} \right] \end{aligned} \right) \left[\prod_{j=0}^N \phi_j(\theta_j) \right] d\theta_0 \dots d\theta_N \\
& = -U_0^*(\underline{\theta}_0) - \sum_{i=1}^N [U_i^*(\bar{\theta}_i) - \omega_i].
\end{aligned}$$

In (70), $U_0^*(\underline{\theta}_0)$ is the expected net payoff of the entrepreneur, given that his type is $\underline{\theta}_0$, and $U_i^*(\bar{\theta}_i)$ is the expected payoff of bureaucrat i , given that $\bar{\theta}_i$ is his type – both under the mechanism Γ^* . Note that the last line in (70) has been obtained by using the result that the integral in (70) is equal to 0. Furthermore, recall that $\theta_0^* = \underline{\theta}_0$ when $\theta_0 = \underline{\theta}_0$, which implies that $U_0^*(\underline{\theta}_0) = 0$. Recall also that for each $i = 1, \dots, N$, if $\theta_i = \bar{\theta}_i$, then $\theta_i^* = \bar{\theta}_i$, which implies that $U_i^*(\bar{\theta}_i) = \omega_i$. Hence the expected budget is balanced under the mechanism.

Now let

$$(71) \quad f^*: \theta \rightarrow f^*(\theta) = (q_0^*(\theta), q_1^*(\theta), \dots, q_N^*(\theta), b_0^*(\theta), b_1^*(\theta), \dots, b_N^*(\theta))$$

be the social-choice function defined in the following manner, where

$$(72) \quad q_0^*(\theta) = q_1^*(\theta) = \dots = q_N^*(\theta) = Q(\theta | \alpha^*).$$

To show that f^* maximizes the expected total gains from trade among Bayesian incentive compatible social-choice functions that satisfy the interim individual rationality constraints and the expected balanced budget constraint, let f be another social-choice function that satisfies all these requirements. Then (49) must hold for f . Hence f is a feasible candidate for the constrained maximization problem constituted by (56) and (57), and thus the expected total gains from trade under f cannot exceed

that generated under f^* . We summarize the results just obtained in the following proposition.

PROPOSITION 3: *The social-choice function f^* is truthfully implementable in dominant strategies. Furthermore, it maximizes the expected total gains from trade among the class of social-choice functions that are (i) Bayesian incentive compatible; (ii) satisfy the interim individual rationality constraints; and (iii) satisfy the expected balanced budget constraint.*

In what follows, we shall refer to the game induced by the social-choice function f^* as the dominant-strategy game and denote it by Γ^* . In the game Γ^* , the expected bribe payments – as a function of his own type – made by the entrepreneur are given by

$$(73) \quad \bar{b}_0^*(\theta_0) = \int (1-p)Q(\theta_0, \theta_{-0})b_0^*(\theta_0, \theta_{-0})d\Phi_{-0}(\theta_{-0}).$$

It follows directly from the definition of $b_0^*(\theta)$ that $\bar{b}_0^*(\theta_0)$ is increasing in θ_0 . As for the expected bribe received by bureaucrat i in the game Γ^* , it is given by

$$(74) \quad \bar{b}_i^*(\theta_i) = \int (1-p)Q(\theta_i, \theta_{-i})b_i^*(\theta_i, \theta_{-i})d\Phi_{-i}(\theta_{-i}), \quad (i = 1, \dots, N).$$

It follows directly from the definition of $b_i^*(\theta)$ that $\bar{b}_i^*(\theta_i)$ is decreasing in θ_i .

In the literature on the economics of corruption it is often argued that to fight corruption the authorities should adopt a more vigorous stand on law enforcement to catch corrupt public officials.³¹ Obviously, if $p = 1$, i.e., if corrupt acts are always detected, then a public official who engages in these illegal acts will certainly be caught, and his payoff will be $-\theta_i < 0$. A negative payoff implies that the interim rationality constraint will be violated, and thus no bureaucrat will engage in these illegal acts. Thus by a continuity argument, we can assert that if law enforcement is vigorous enough, the probability of detection will be high, and no bureaucrat will want to risk his job and good name by engaging in corrupt activities.

³¹ One of the important contributions on this subject is Mookherjee and Png (1995).

Another argument which is often advocated in the literature on the economics of corruption is that to curb corruption public-sector wages should be raised.³² A high wage in the public sector means that a public official has much to lose if he engages in corruption activities and is caught and dismissed from his job. The efficiency wage argument is based solely on the utility maximization behaviour of a corrupt bureaucrat, who takes as given the bribe offered to him. No attempt is made to model the behaviour of the entrepreneur. There is no bargaining for bribes and bribe payments, either. Our analysis, which is conducted in an asymmetric-information setting in which the an entrepreneur and a track of bureaucrats negotiate with each other about bribe payments and bribe receipts, supports the efficiency wage argument, and is stated formally in the following proposition:

PROPOSITION 4: *Suppose that θ_0 is uniformly distributed on the unit interval $[0,1]$.³³ If the probability of detection is small, then a rise in the wage rate of a bureaucrat reduces the likelihood of trade; that is, the higher the wages in the public-sector, the lower will be the probability that corruption will occur.*

PROOF: First, recall that the probability of trade between the entrepreneur and the track of bureaucrats is given by $Q(\theta | \alpha^*)$, where α^* is the value of α such that the curve $G : \alpha \rightarrow G(\alpha)$, $0 \leq \alpha \leq 1$, crosses the horizontal axis. Next, recall that trade will take place if and only if $c_0(\theta | \alpha^*) \geq \sum_{i=1}^N c_i(\theta | \alpha^*)$, i.e., if and only if

$$(75) \quad (1-p)\theta_0 - p \sum_{i=1}^N (\omega_i + \theta_i) \geq \alpha^* \left[(1-p) \frac{1 - \Phi_0(\theta_0)}{\phi_0(\theta_0)} + p \sum_{i=1}^N \frac{\Phi_i(\theta_i)}{\phi_i(\theta_i)} \right].$$

Note that the left side of (75) represents the total gain from trade, as a function of the type profile θ . According to Proposition 3, trade will only take place if the total gain from trade is at least equal to the right side of (75). To prove Proposition 4, we shall

³² Van Rijckeghem and Weder (2001) examined the relationship between the level of public sector wages and corruption. In a small sample of 31 developing countries, they found the evidence that there is a significant negative correlation between civil servants' wages and corruption level.

³³ The proposition can be proved for a more general distribution function. However, the proof requires considerably more effort.

show that a rise in the wage of a bureaucrat, say bureaucrat i , induces a rise in α^* . The rise in α^* coupled with the rise in ω_i make it less likely for (75) to hold, i.e., a rise in the wage of a bureaucrat reduces the probability that corruption will occur.

To study the influence of ω_i on the likelihood that trade will take place, we will make the dependence of the curve G on both ω_i and α explicit, and write (61) as

$$(76) \quad G(\omega_i, \alpha) = \int_{\underline{\theta}_0}^{\bar{\theta}_0} \dots \int_{\underline{\theta}_N}^{\bar{\theta}_N} Q(\theta | \alpha) \left(\begin{array}{l} (1-p) \left[\theta_0 - \frac{1-\Phi_0(\theta_0)}{\phi_0(\theta_0)} \right] \\ - p \sum_{i=1}^N \left[\omega_i + \theta_i + \frac{\Phi_i(\theta_i)}{\phi_i(\theta_i)} \right] \end{array} \right) \left[\prod_{j=0}^N \phi_j(\theta_j) \right] d\theta_0 \dots d\theta_N$$

$$= \int_{\underline{\theta}_N}^{\bar{\theta}_N} \dots \int_{\underline{\theta}_1}^{\bar{\theta}_1} H(\omega_i, \alpha, (\theta_j)_{j=1}^N) \left[\prod_{j=1}^N \phi_j(\theta_j) \right] d\theta_1 \dots d\theta_N,$$

where we have let

$$(77) \quad H(\omega_i, \alpha, (\theta_j)_{j=1}^N) = \int_{\hat{\theta}_0(\omega_i, \alpha, (\theta_j)_{j=1}^N)}^{\bar{\theta}_0} \left(\begin{array}{l} (1-p) \left[\theta_0 - \frac{1-\Phi_0(\theta_0)}{\phi_0(\theta_0)} \right] \\ - p \left[\omega_i + \theta_i + \frac{\Phi_i(\theta_i)}{\phi_i(\theta_i)} \right] \\ - p \sum_{j=1, j \neq i}^N \left[\omega_j + \theta_j + \frac{\Phi_j(\theta_j)}{\phi_j(\theta_j)} \right] \end{array} \right) d\theta_0.$$

Note that $\hat{\theta}_0(\omega_i, \alpha^*(\omega_i), (\theta_j)_{j=1}^N)$, the lower limit of the integral in (77), is the value of θ_0 defined implicitly by

$$(78) \quad (1-p) \left[\theta_0 - \alpha \frac{1-\Phi_0(\theta_0)}{\phi_0(\theta_0)} \right] - p \left[\omega_i + \theta_i + \alpha \frac{\Phi_i(\theta_i)}{\phi_i(\theta_i)} \right] - p \sum_{j=1, j \neq i}^N \left[\omega_j + \theta_j + \alpha \frac{\Phi_j(\theta_j)}{\phi_j(\theta_j)} \right] = 0.$$

The unique value of α such that $G(\omega_i, \alpha) = 0$ now depends on ω_i , and will be written as $\alpha^*(\omega_i)$. It follows from the definition of α^* that $G(\omega_i, \alpha^*(\omega_i)) = 0$. Differentiating $G(\omega_i, \alpha^*(\omega_i))$ with respect to ω_i , then solving for $D\alpha^*(\omega_i)$, we obtain

$$(79) \quad D\alpha^*(\omega_i) = -\frac{D_1 G(\omega_i, \alpha^*(\omega_i))}{D_2 G(\omega_i, \alpha^*(\omega_i))}.$$

Because the derivative in the denominator of the expression on the right side of (79) is positive, $D\alpha^*(\omega_i)$ will be positive if the derivative in the numerator of this expression is negative, and this is what we now try to establish.

Now for any given value of α , differentiating $H(\omega_i, \alpha, (\theta_j)_{j=1}^N)$ with respect to ω_i , we obtain

$$(80) \quad D_1 H(\omega_i, \alpha, (\theta_j)_{j=1}^N) = \int_{\hat{\theta}_0(\omega_i, \alpha, (\theta_j)_{j=1}^N)}^{\bar{\theta}_0} -p d\theta_0 \left(\begin{array}{l} \hat{\theta}_0(\omega_i, \alpha, (\theta_j)_{j=1}^N) \\ (1-p) \left[\frac{1 - \Phi_0(\hat{\theta}_0(\omega_i, \alpha, (\theta_j)_{j=1}^N))}{\phi_0(\hat{\theta}_0(\omega_i, \alpha, (\theta_j)_{j=1}^N))} \right] \\ -D_1 \hat{\theta}_0(\omega_i, \alpha, (\theta_j)_{j=1}^N) - p \left[\omega_i + \theta_i + \frac{\Phi_i(\theta_i)}{\phi_i(\theta_i)} \right] \\ -p \sum_{j=1, j \neq i}^N \left[\omega_j + \theta_j + \frac{\Phi_j(\theta_j)}{\phi_j(\theta_j)} \right] \end{array} \right).$$

To evaluate the derivative $D_1 \hat{\theta}_0(\omega_i, \alpha, (\theta_j)_{j=1}^N)$, we differentiate (78) implicitly with respect to ω_i to obtain

$$(81) \quad (1-p)[1 - \alpha \phi_0'(\theta_0)] D_1 \hat{\theta}_0(\omega_i, \alpha, (\theta_j)_{j=1}^N) - p = 0,$$

where we have let

$$(82) \quad \varphi_0(\theta_0) = \frac{1 - \Phi_0(\theta_0)}{\phi_0(\theta_0)}.$$

It follows from (82) that

$$(83) \quad D_1 \hat{\theta}_0(\omega_i, \alpha, (\theta_j)_{j=1}^N) = \frac{p}{(1-p)[1-\alpha\varphi_0'(\theta_0)]}.$$

Using (83) in (80), we can rewrite the latter expression as

$$(84) \quad D_1 H(\omega_i, \alpha, (\theta_j)_{j=1}^N) = - \int_{\hat{\theta}_0(\omega_i, \alpha, (\theta_j)_{j=1}^N)}^{\bar{\theta}_0} p d\theta_0 - \frac{p}{(1-p)[1-\alpha\varphi_0'(\hat{\theta}_0(\omega_i, \alpha, (\theta_j)_{j=1}^N))]} \left(\begin{aligned} & \left[\hat{\theta}_0(\omega_i, \alpha, (\theta_j)_{j=1}^N) \right. \\ & \left. (1-p) \frac{1-\Phi_0(\hat{\theta}_0(\omega_i, \alpha, (\theta_j)_{j=1}^N))}{\phi_0(\hat{\theta}_0(\omega_i, \alpha, (\theta_j)_{j=1}^N))} \right] \\ & - p \left[\omega_i + \theta_i + \frac{\Phi_i(\theta_i)}{\phi_i(\theta_i)} \right] \\ & - p \sum_{j=1, j \neq i}^N \left[\omega_j + \theta_j + \frac{\Phi_j(\theta_j)}{\phi_j(\theta_j)} \right] \end{aligned} \right).$$

Dividing (84) by p , then rearranging the result, we obtain

$$(85) \quad \begin{aligned} \frac{D_1 H(\omega_i, \alpha, (\theta_j)_{j=1}^N)}{p} &= -\bar{\theta}_0 + \\ &+ \frac{p \sum_{j=1}^N \left[\omega_j + \theta_j + \frac{\Phi_j(\theta_j)}{\phi_j(\theta_j)} \right]}{(1-p)[1-\alpha\varphi_0'(\hat{\theta}_0(\omega_i, \alpha, (\theta_j)_{j=1}^N))]} \\ &- \frac{1}{1-\alpha\varphi_0'(\hat{\theta}_0(\omega_i, \alpha, (\theta_j)_{j=1}^N))} \left[\frac{\alpha\varphi_0'(\hat{\theta}_0(\omega_i, \alpha, (\theta_j)_{j=1}^N))\hat{\theta}_0(\omega_i, \alpha, (\theta_j)_{j=1}^N)}{\phi_0(\hat{\theta}_0(\omega_i, \alpha, (\theta_j)_{j=1}^N))} \right. \\ &\quad \left. - \frac{1-\Phi_0(\hat{\theta}_0(\omega_i, \alpha, (\theta_j)_{j=1}^N))}{\phi_0(\hat{\theta}_0(\omega_i, \alpha, (\theta_j)_{j=1}^N))} \right]. \end{aligned}$$

Using the assumption that θ_0 is uniformly distributed on the unit interval $[0,1]$, we have the following results $\Phi_0(\theta_0) = \theta_0$, $\varphi_0(\theta_0) = 1$, and $\varphi_0'(\theta_0) = 1$, which can be used to simplify (85) as follows

$$\begin{aligned}
(86) \quad \frac{D_1 H(\omega_i, \alpha, (\theta_j)_{j=1}^N)}{p} &= -1 + \frac{p}{(1-p)(1+\alpha)} \sum_{j=1}^N \left[\omega_j + \theta_j + \frac{\Phi_j(\theta_j)}{\phi_j(\theta_j)} \right] \\
&\quad + \frac{1}{1+\alpha} \left[1 - (1-\alpha) \hat{\theta}_0(\omega_i, \alpha, (\theta_j)_{j=1}^N) \right] \\
&= -\frac{\alpha}{1+\alpha} - \frac{(1-\alpha) \hat{\theta}_0(\omega_i, \alpha, (\theta_j)_{j=1}^N)}{1+\alpha} + \frac{p}{(1-p)(1+\alpha)} \sum_{j=1}^N \left[\omega_j + \theta_j + \frac{\Phi_j(\theta_j)}{\phi_j(\theta_j)} \right].
\end{aligned}$$

Now for any given value of $\alpha, 0 < \alpha < 1$, the last line in (86) will be negative when p is sufficiently small. We have just shown that for any given value of $\alpha, 0 < \alpha < 1$, the inequality $D_1 H(\omega_i, \alpha, (\theta_j)_{j=1}^N) < 0$ holds when p is sufficiently small. Using the preceding inequality in the multiple integral on the second line of (76), we can then assert that $D_1 G(\omega_i, \alpha) < 0$. In particular, for $\alpha = \alpha^*(\omega_i)$, we have $D_1 G(\omega_i, \alpha^*(\omega_i)) < 0$, as desired. ■

3.3.3 The Second-Best Mechanism with Actual Balanced Budget Constraint

Under the mechanism described by Proposition 3, the expected bribes paid by the entrepreneur are equal to the expected value of the sum of the bribes that the N bureaucrats receive. There is no guarantee that actual payments by the entrepreneur are equal to the sum of actual bribes received by the track of bureaucrats for each possible realization of θ . Thus we must go further to find a mechanism that fulfils the requirement that actual payments by the entrepreneur are equal to the sum of actual bribes received by the track of bureaucrats. To accomplish this task, we create another game with a Bayesian Nash equilibrium that is the same as the equilibrium of the game with dominant strategies described in the preceding sub-section.³⁴

To this end, let us consider the following game with incomplete information. In this game, that we call $\Gamma^\#$, each agent is asked to reveal his type. If $\theta = (\theta_0, \theta_1, \dots, \theta_N)$ is the announced profile of types, then the arbitrator allows trade to take place with probability

³⁴ The analysis used to find this mechanism draws on the technique developed by Bulow and Roberts (1989) for the bilateral trading model of Myerson and Satterthwaite (1983).

$Q(\theta | \alpha^*)$, as in the game with dominant strategies analyzed in the preceding subsection. However, in contrast with the dominant-strategy game, the following transfers are made, whether trade takes place or not:

For the entrepreneur, the transfer he receives in the new game is given by

$$(87) \quad b_0^\#(\theta) = \bar{b}_0^*(\theta_0) - \sum_{i=1}^N \bar{b}_i^*(\theta_i) + \sum_{i=1}^N \int \bar{b}_i^*(\theta_i) d\Phi_i(\theta_i).$$

For bureaucrat i , the transfer he receives is

$$(88) \quad b_i^\#(\theta) = \bar{b}_i^*(\theta_i) - \frac{1}{N} [\bar{b}_0^*(\theta_0) - \int \bar{b}_0^*(\theta_0) d\Phi_0(\theta_0)], \quad (i = 1, \dots, N).$$

Now if $\theta = (\theta_0, \dots, \theta_i, \dots, \theta_N)$ is the true type profiles of the agents, and if bureaucrat i chooses to announce θ_i' as his type while all the other agents reveal their types truthfully, then his payoff in the game $\Gamma^\#$ will be

$$(89) \quad \begin{aligned} & -p\theta_i + (1-p)b_i^\#(\theta_0, \dots, \theta_i', \dots, \theta_N) + (1-p)\omega_i \\ & = -p\theta_i + (1-p) \left[\bar{b}_i^*(\theta_i') - \frac{1}{N} [\bar{b}_0^*(\theta_0) - \int \bar{b}_0^*(\theta_0) d\Phi_0(\theta_0)] \right] + (1-p)\omega_i, \end{aligned}$$

which yields the following expected payoff

$$(90) \quad \begin{aligned} & \int \left(-p\theta_i + (1-p) \left[\bar{b}_i^*(\theta_i') - \frac{1}{N} [\bar{b}_0^*(\theta_0) - \int \bar{b}_0^*(\theta_0) d\Phi_0(\theta_0)] \right] + (1-p)\omega_i \right) d\Phi_0(\theta_0) \\ & = -p\theta_i + (1-p)\bar{b}_i^*(\theta_i') + (1-p)\omega_i \\ & \leq -p\theta_i + (1-p)\bar{b}_i^*(\theta_i) + (1-p)\omega_i. \end{aligned}$$

Note that the expression on the second line of (90) is the expected payoff for this bureaucrat in the dominant-strategy game if he announces θ_i' as his type. Also, the expression on the last line of (90) represents the expected payoff he receives in the dominant-strategy game by revealing his type truthfully. Hence in the game $\Gamma^\#$ being truthful – when all the other agents are truthful – is a best response for bureaucrat i .

To show that in the game $\Gamma^\#$ being truthful is also a best response for the entrepreneur – when all the other agents are truthful – let θ_0' be the type he chooses to announce. If

$Q(\theta_0', \theta_1, \dots, \theta_N) = 0$, then his payoff consists only of the transfer he receives, namely $b_0^\#(\theta_0', \theta_1, \dots, \theta_N)$. On the other hand, if $Q(\theta_0', \theta_1, \dots, \theta_N) = 1$, then the arbitrator allows trade to take place, and the payoff he obtain – in addition to the transfer he receives – also includes the benefit yielded by the project if it comes to fruition without the bribery act being detected. That is, the expected payoff obtained by the entrepreneur if he announces θ_0' as his type is given by

$$\begin{aligned}
(91) \quad & \int_{\{(\theta_1, \dots, \theta_N) | Q(\theta_0', \theta_1, \dots, \theta_N) = 0\}} b_0^\#(\theta_0', \theta_1, \dots, \theta_N) d\Phi_{-0}(\theta_1, \dots, \theta_N) \\
& + \int_{\{(\theta_1, \dots, \theta_N) | Q(\theta_0', \theta_1, \dots, \theta_N) = 1\}} [(1-p)\theta_0 + b_0^\#(\theta_0', \theta_1, \dots, \theta_N)] d\Phi_{-0}(\theta_1, \dots, \theta_N) \\
& = \bar{b}_0^\#(\theta_0') + \int_{\{(\theta_1, \dots, \theta_N) | Q(\theta_0', \theta_1, \dots, \theta_N) = 1\}} (1-p)\theta_0 d\Phi_{-0}(\theta_1, \dots, \theta_N) \\
& \leq \bar{b}_0^\#(\theta_0') + \int_{\{(\theta_1, \dots, \theta_N) | Q(\theta_0', \theta_1, \dots, \theta_N) = 1\}} (1-p)\theta_0 d\Phi_{-0}(\theta_1, \dots, \theta_N).
\end{aligned}$$

Note that the third line in (91) represents the expected net payoff in the dominant-strategy game that the entrepreneur obtains if he announces θ_0' as his type. If he is truthful in the game $\Gamma^\#$, then his expected net payoff he obtains will be given by the last line in (91), which is exactly the net expected payoff he receives in the dominant-strategy game. We have just shown that the strategy profile in which each agent reveals his type truthfully constitutes a Bayesian Nash equilibrium of the game $\Gamma^\#$. Under this Bayesian Nash equilibrium, the sum of the transfers to all the agents – for any type profile θ – is given by

$$\begin{aligned}
(92) \quad & b_0^\#(\theta) + \sum_{i=1}^N b_i^\#(\theta_i) = \bar{b}_0^*(\theta_0) - \sum_{i=1}^N \bar{b}_i^*(\theta_i) + \sum_{i=1}^N \int \bar{b}_i^*(\theta_i) d\Phi_i(\theta_i) \\
& + \sum_{i=1}^N \bar{b}_i^*(\theta_i) - [\bar{b}_0^*(\theta_0) - \int \bar{b}_0^*(\theta_0) d\Phi_0(\theta_0)] \\
& = \sum_{i=1}^N \int \bar{b}_i^*(\theta_i) d\Phi_i(\theta_i) + \int \bar{b}_0^*(\theta_0) d\Phi_0(\theta_0) = 0.
\end{aligned}$$

Note that the last equality in (92) follows from the fact that the expected budget is balanced in the dominant-strategy game. Hence in the game $\Gamma^\#$, regardless of the

profiles of types, the actual budget is always balanced. We summarize the results just obtained in the following proposition:

PROPOSITION 5: In the game $\Gamma^\#$, the strategy profile in which all agents – entrepreneur and bureaucrats – reveal their types truthfully constitutes a Bayesian Nash equilibrium. Under this Bayesian Nash equilibrium, the actual budget is balanced for each type profile announced. Furthermore, the probability that trade takes place is under the game $\Gamma^\#$ is the same as the probability that trade takes place under the dominant-strategy game. Also, the expected payoffs of each agent are the same under both games. Finally, in contrast with the dominant-strategy game – in which no money changes hands if trade does not take place – transfers from the entrepreneur to the bureaucrats do take place even if trade does not occur.

A rather unpleasant feature of the game $\Gamma^\#$ is that bribes are paid even when trade does not occur. Also, the equilibrium now is a Bayesian Nash equilibrium, not an equilibrium in dominant strategies. These are the prices we pay for achieving the actual balanced budget constraint, in addition to the participation constraint. In spite of this unpleasant feature, the payoff structure in the game $\Gamma^\#$ does have some intuitive properties. First, note that the higher is the type of the entrepreneur, ceteris paribus, the higher is the total expected bribe payments he makes under the game $\Gamma^\#$. Second, note that the higher is the type of a bureaucrat, ceteris paribus, the lower is the expected bribe he receives under the game $\Gamma^\#$. Loosely speaking, these two results together imply that every other thing equal, the entrepreneur pays more when his type is higher, and a bureaucrat receives a higher bribe when his moral cost is lower.

3.4 CONCLUSION

In this essay, we formulate and analyze a model of entry regulation that involves an entrepreneur and a track of corruptible bureaucrats. The model is formulated under the framework of mechanism design, and is based on the work on bilateral trading under asymmetric information of Myerson and Satterthwaite (1983). The bargaining between the entrepreneur and the track of bureaucrats is modelled by introducing a fictitious arbitrator who asks each agent – entrepreneur and bureaucrats – to reveal his type, and makes the transfers according to the profile of types announced.

Under our original game settings, we discover that there is no social choice function that is Bayesian incentive compatible; satisfies the interim individual rationality constraints; and is ex post efficient. Next, we construct a second-best mechanism that maximizes the total gain from trade subject to the constraints that (i) it is Bayesian incentive compatible; (ii) satisfies the interim individual rationality constraints; and satisfies the balanced budget constraint. The mechanism we find is truthfully implementable in dominant strategies and satisfies the interim individual rationality constraints. Under this second-best mechanism, no money changes hands if trade does not take place. However, the mechanism only satisfies the expected balanced budget constraint, not the actual balanced budget constraint. Now because bribery is an illegal act, it is not possible to achieve the actual balanced budget constraint by appealing to outside sources of financing, say a subsidy from a third party, and thus a mechanism that satisfies the actual balanced budget constraint must be found.

To solve the problem of actual balanced budget constraint, we create another mechanism that yields the same probability of trade and the same expected payoff for each agent as the dominant-strategy game. The payoffs structured under the new mechanism we find is such that (i) each agent finds it in his interest to reveal his type truthfully, if all the other agents choose to reveal their types truthfully; (ii) each agent is willing to participate in the mechanism; and (iii) the actual bribe payments by the entrepreneur are equal to the actual total bribes receipts. The actual balanced budget

constraint has been obtained by weakening the mechanism that is truthfully implementable in dominant strategies. The equilibrium in the new mechanism is now only a Bayesian Nash equilibrium, not an equilibrium in dominant strategies. In the new second-best the entrepreneur has to pay even if trade does not take place.

The mechanism we propose does not touch on the possibility of the breach of commitments; that is, the entrepreneur pays the bribes, but does not get the permit from the track of bureaucrats, since the commitments constitute an implicit contract that has no enforcement power. We believe that our model can be used to analyze problems of entry regulation in developing countries. Our model can be extended in several directions. First, the model can be extended to include more than one entrepreneur competing for the same project. In this case, the game will be a tournament bidding game. It would be the entrepreneur that has the highest willingness to pay for entrance win the game. In that sense, the bribery bidding is more intense than that of our model. Second, our model can be extended into a dynamic setting – as a repeated game – with a sequence of entrepreneurs applying to the same track of bureaucrats for a permit. These are the subjects for our future research.

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CONCLUSION REMARKS

TO CONCLUDE, we make a brief summary of our three essays. Our essays evaluate the effect of corruption in the three different institutional settings from the perspectives of the applied microeconomic theory using a mechanism design approach. In reality, there are many unsolved corruption related principal-agent problems in our society. Our thesis can be applied to tackling these principal-agent problems under the different institutional settings. Our three essays try to answer the questions that result from the asymmetric information between principal and agents. Our analysis primarily focuses on the administrative corruption and applies the mechanism design approach to explain why corruption occurs and what the mechanism behind the corruption is. Furthermore, our analyses could be used to help understand the mechanism of corruption and therefore how to curb corruption under the different institutional settings.

A relationship exists between our research and a more general framework; in particular, collusion in an organization is also a form of corruption. Recent development in principal-agent theory sheds light on the important role of contracts that prevent collusive actions in various economic situations. This theory explains how a principal who offers a contract to an agent should design an optimal contract to eliminate the asymmetries of information between the principal and the agents. According to Tirole (1986), organizations can be seen as a network of overlapping or nested principal/agent relationships, i.e., as a network of coalitions and contracts that interplay in the context of principal-agent theory. Tirole's point of view on organization is useful in understanding and designing the optimal incentive contracts. In reality, there are many situations in which collusion plays an important role in organization, and according to Tirole (1996), a theory of collusion in organizations is needed. Because collusion is the realization of gains from trade within groups of an organization, we need to understand how agent reacts to the rules of an organization, and how a principal who is aware of the incentives for collusion should design the optimal incentive mechanisms for the organization. The key to designing the optimal mechanism in an organization is to find

a revelation mechanism which induces all agents to reveal truthfully their private information. For example, Laffont and Tirole (1993) and Laffont (2005) apply the revelation principle in several economic contexts, including the interaction between a regulatory authority and the firms it regulate. In the absence of limitation on contracts, but with decentralized information, the revelation mechanism can be used to ensure that any organization can achieve the results obtained by a centralized organization in which information must be communicated in an incentive-compatible way to the center. Although the center is assumed to be able to control communication between agents, the center cannot succeed in this task completely. In this thesis, we concentrate only on the corrupting behavior of the agents and leave the behavior of the principal, especially the important subject of optimal incentive contracts in an organization for future research.

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