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M.I. LEVIN AND M.L. TSIRIK

Corruption as an Object of Mathematical Modeling

[Abstract:] *The article considers the problems of modeling corruption as a socioeconomic and political phenomenon and surveys existing approaches to modeling and the phenomenon of corruption. Approaches to the use of basic categories and concepts connected with corruption are presented. An attempt is made to classify mathematical models of corruption, and the basic model of corruption and some modifications of it are explained.*

1. Corruption is a socioeconomic phenomenon

At present, none of the questions connected with corruption—from what it is, where it appears, and why, to what are the consequences of this phenomenon for society?—have canonical answers. For a long time, the very concept of corruption was a subject of numerous discussions among economists, political scientists, sociologists, and other social scientists. If the bribery of a government bureaucrat can be classified as “corruption” (and the proper punishment can be specified by law), then what can we say, for example, about re-

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ceptions for the press or some company's potential business partners? Most often, the authors of books and articles devoted to corruption look at the "traditional" type—government (namely, bureaucratic and political) corruption, which [1] is considered as old as the history of government authority itself and includes, among other things, trading in licenses, votes, administrative and judicial rulings, and government jobs.

1.1. What is corruption?

Government corruption is defined in [2] as the sale of state property for private purposes by government employees. For example, government employees often take bribes when issuing licenses or customs permits, or bribes for preventing competitors of the company giving the bribe from entering the market. In these cases, they are personally assigning to private agents payment for goods that officially belong to the state.

Corruption (according to [1]) is a general term designating the selfish use of one's position in society for personal purposes. This may be *bureaucratic* or *political* corruption. The corrupt party receives a bribe for a service that he makes available. As is noted in S. Rose-Ackerman's article [3], the party receiving the bribe must be an *agent* for another party or organization, because the purpose of a bribe is to induce him to put his own interests above the goals of the organization for which he works. In order to be a subject of bribery, the party to be bought off must have some power, which he may get either due to imperfection of the market or through his own institutional position. A bribe, of course, is not necessarily money; it may be a "gift" or an offer of employment, favors to relatives, and so forth. This phenomenon may also be called corruption if we are talking about a private company, rather than a state one. Although, as is noted in [1], there is no general agreement in business on interpreting payments of this sort as a bribe. To some, this seems like an "ordinary" or "normal" payment for service. Others consider a bribe to be a "dubious" act (but only from the moral point of view). Still others are inclined to interpret it as an act worthy of reproach from the standpoint of the professional etiquette of the free market. And some speak unequivocally of a crime that must be subject to the inevitable penalty of law (quoted from [1]). But according to [3], corruption in the private market is usually not regulated by law, and a representative of one company may bribe a representative of another one, although the companies themselves do have the right to fire the guilty employees.

Different types of corruption are distinguished, and this classification can be carried out at various levels.

1. At the level of individual acts, we can distinguish three types of corrup-

tion. In [4], S. Rose-Ackerman defined it as the collection of personal "tariffs" charged for doing what official rules require to be done free of charge (for example, payment for a visa that is formally free can be considered a "tariff"), or the collection of personal "tariffs" charged for not doing what the rules require to be done (so, a bribe for an auditor to conceal important information is also a "tariff"). Or, it can be "tariffs" for actions that directly *violate* laws, for example, in return for a bribe ("tariff"), a tax inspector may submit a false report on the income of a taxpayer who has bought him off.

2. Corruption can be *internal* or *external*. Internal corruption occurs between members of the same organization; external corruption is bribery of a member of an organization by someone from the outside (according to [5], J. Tirole defined external corruption as an independent and personal violation of duty; and internal corruption, as an organizational crime).

3. Corruption can be *government* (bureaucratic or political) corruption, if we are talking about a government organization, or *corruption in the private sector*.

4. Speaking of government corruption connected with the structure of different governments, we will use the division given by S. Rose-Ackerman in [6]. She distinguishes two traits according to which corrupted societies can be differentiated: (1) according to the type of people who take bribes: (a) a kleptocracy, in which corruption is organized at the top of the government, and (b) countries where corruption is the sphere of activity of a large number of bureaucrats; (2) according to the type of "market" for bribes: (a) a small number of key individuals are engaged in corruption, and (b) payments of bribes are decentralized. These two traits correspond to four categories of corrupted governments: a kleptocracy, a competitive market, a dual monopoly, and a very weak government controlled by the mafia.

5. And finally, corruption can show up at the supragovernmental, *international* level. In the world community, corruption in the sphere of international business is a special problem. International agreements have been made between interacting countries to try to eliminate it.

1.2. Causes of corruption and situations in which it occurs

What causes corruption to appear? The simple answer given by most researchers of corruption is that the government is the cause of corruption, that is, various restrictions, regulations, and controls imposed on free economic agents. Following the economic approach, that is, assuming that everyone maximizes his own profit, we can come to the conclusion that corruption is a natural economic phenomenon connected with the presence of government.

The government, which is called upon to correct inefficiency and market failures, can itself cause corruption and inefficiency.

From the economic point of view, corruption is a manifestation of rent-seeking behavior. Such behavior accompanies processes of competition for a government contract, or an export or import quota, but it can be the result of a private company's desire to avoid some tax (then corruption is the dark shadow of taxation, as is shown in the work of A. Shleifer and R.W. Vishny [2]).

As follows from [6], there are six most common situations that create motives for corruption, in other words, for bringing the market rule of "rent seeking" into government regulation.

—The government may prescribe the allocation of scarce rent to a large number of individuals and companies, using formal criteria, and not the desire to pay for the rent to be distributed. *Bribes rectify the market.*

—Bureaucrats in the public sector may be poorly motivated to do their job well, due to low pay and a low level of internal supervision. *Here, bribes act as bonuses.*

—Private companies and individuals try to lower the costs imposed on them by the government, in the form of taxes and consumer rules and regulations. *Bribes lower costs for those who pay them.*

—The government often turns over large financial profits to private companies through contracts, privatization, and awarding concessions. *Bribes influence the level of monopoly rents and their division among private investors and public bureaucrats.*

—Bribes can replace legal forms of political influence. *Bribery of politicians buys their influence, and bribery by politicians is vote-buying.*

—Justice has the power to impose costs and redistribute resources between parties. *Bribes can override legal standards.*

So, the government's interference creates restrictions for the private market, and, consequently, the motives to violate these restrictions; therefore, economic agents themselves are often interested in bribing a bureaucrat. Such methods of government regulation of the market as, for example, issuing permits or licenses leads to a situation in which the monopolist bureaucrat who holds the right to issue the permit has the opportunity to use his position for personal gain. Thus, the bureaucrat, just as the agent, has a motive to violate his obligations to the state.

When does such a mutual or unilateral desire lead to a corrupt deal? According to R. Klitgaard [7], the conditional corruption equation can be **corruption = monopoly + freedom of action – accountability**. A bureaucrat's monopoly over a service that a company needs and, simultaneously, a lack of supervision of the bureaucrat lead to a deal. This thought is corroborated in [2, 8]. In a government (often, consequently, a monopoly) organization, in-

structions are often rather vague. Such leeway leads to situations in which the bureaucrat's hands are "untied." Monopolism of a similar kind in a private company leads to analogous consequences. But, according to E.C. Banfield's article [9], which takes a close look at the difference between a business organization and a government one and the possibilities of corruption in them, such possibilities are much broader in the latter. This is connected with the considerable fragmentation of power in a government organization. Moreover, in connection with the indistinct boundaries of a bureaucrat's authority, there is no opportunity to check the validity of the decisions that he makes, because a reasonable and plausible explanation can be given for almost all of them. At the same time, in addition to monetary profit, an employee of a government organization may pursue other goals, for example, reelection for a new term. In this case, rejection of bribes and even demonstration of such rejection may be considered a certain equivalent of a bribe itself, as G. Feichtinger and F. Wirl showed [8]. An interesting difference between these two types of organizations is that it is believed that corruption in a government organization must be eliminated by any means, while in relation to a business organization the goal is not minimization, but optimization of the level of corruption, that is, expenditures on measures to prevent and decrease corruption are commensurate with the profit obtained from these measures.

The literature on corruption studies situations when it is caused by government regulation aimed at what we can call two opposite goals. First of all, government regulation is supposed to be optimum and aimed at eliminating existing market failures (for example, environmental pollution, which is investigated in the work of D. Mookherjee and I.P. Png [10]). And second, cases are considered in which government regulation is nonoptimum in principle.

As follows from analysis of the model suggested in D. Acemolgu and T. Verdier's work [11], even with the optimum structure of society rents (inflated salaries) for government bureaucrats, a certain portion of corruption and less than the best allocation of individual talents will be present in it. Moreover, these same authors have proved [12] that all of these consequences (the presence of corrupt bureaucrats, rent in the public sector, and nonoptimum allocation of talents) still are not sufficient proof that society should avoid government interference, because the government's "failures" described above are still better than the market failures that the government is trying to eliminate.

It is a curious fact that government regulation may be aimed at extracting bribes from the beginning. According to [1], many specialists believe that the main cause of corruption is the growing army of bureaucrats, bureaucratization of public life, and unjustified expansion of the role of government. As was mentioned in the article by L. Hillman and F. Katz [13], back in 1965, G. Tullock noted that, because bureaucrats' profits grow with the number of their

subordinates, this encourages an increase in the bureaucratic hierarchy without an accompanying rise in public benefit. V. Tanzi [14] analyzes the phenomenon of corruption and maintains that, in order to decrease it, it is necessary to radically diminish the role of government in the economy and reduce the size of the public sector. S.N.S. Cheung [15] claims that, because every politician and bureaucrat maximizes his own profit, most rules, quotas, and the like are specially created to raise the income of these bureaucrats through bribes.

Thus, the question of the optimum nature of government regulation is a key point in studying the causes of corruption, and this depends on the specific situation in a specific country. In studying the causes of corruption, one cannot fail to take into account the condition of society as a whole. A market economy, as well as a planned or transitional one (see, for example, the article by B.N. Sands on the role of bureaucratic corruption in the reforms in China), can give rise to corruption. However, the causes of corruption (and also, by the way, the form and consequences of it) may differ significantly.

As M. Johnston contends [17], corruption is a symptom of deeper problems in society, and this is confirmed by empirical data: corruption is closely linked with recessions, a drop in investments, a shortage of creditworthy guarantees of property and contract rights, weak institutionalization of the government, a low level of social interaction and weakness of the law, low competitiveness, deep ethnic divisions and conflicts, a low level of the masses' participation in politics and poor protection of civil rights, a low educational level, and a relatively closed economic and political system.

1.3. Variations in the degree of corruption

Practically all authors of books and articles on corruption agree that it is widespread all over the world and its effect is quite significant. As is pointed out in [2], in a number of developing countries incomes from corruption probably make up a significant portion of gross national product, but we should emphasize that corruption is also commonplace in developed countries. (Some information on corruption in Russia can be drawn from the book by A. Kirpichnikov [18], the articles by M. Levin and G. Satarov [19] and by J. Leitzel [20], and numerous publications in Russian periodicals.) In totalitarian states, among which we can include the former socialist countries, it is hard to draw a boundary between corruption and power, because the more absolute power is, the more corruption grows, and eventually it merges with power or becomes power. As for countries with transitional economies, government corruption in them may develop on a large scale. As was already noted above, one of the main conditions for corruption to appear is the pres-

ence of scarce goods that either cannot be acquired in the free market at the prevailing prices, or, if they can, then only from a discriminating monopolist. Such a phenomenon is characteristic of countries with transitional economies, in which ownership of the means of production and the products of labor formerly belonged to the state and was at the disposal of the bureaucratic machinery. In such countries, to a significant extent, property rights remain highly diffuse during gradual and uncertain privatization, and the privilege to dispose of property remains in the hands of the bureaucratic machinery. Therefore, broad opportunities appear for the bureaucratic machinery to use its privileges that have been preserved to extract personal gain. Obviously, in this case the goal of the bureaucrats differs from the one set for them as representatives of the whole society.

The question of why the degree of corruption is so different in different countries (though they may be similar in some other sense), in different organizations in the same country, and even in different departments of the same organization is very interesting to corruption researchers. For example, the issuing of visas is accompanied by much more corruption than admission to an institute. As M.S. Alarm maintains [21], such differences can be explained in terms of the easy accessibility of countervailing actions for victims of corruption. Such actions can be evading coercion, taking legal action or complaining to the mass media, or counteracting by illegal methods (calling out one's own mafia protection). As is pointed out in [1], the factors that differ in various countries and organizations are "global" factors: human rights, property rights, the level of income and education, and also "specific" factors such as the type of corruption and the number of losers from corruption. "Global" factors can explain the difference in the level of corruption in various countries at various times, while "specific" factors explain these differences in different social organizations. Thus, for example, it is much simpler for students at an institute to create a scandal against corruption than it is for an individual who needs to get a visa.

A difference in the level of corruption can also be explained by the society's past condition, by its history. This effect is modeled in a number of studies, for example, the one by F.T. Lui [22]. In V. Tanzi's article, it says that the level of corruption depends on the society's culture: the more highly personalized relations between people are, the more corrupted the society will be, because bureaucrats constantly experience pressure from their friends and acquaintances.

1.4. Consequences of corruption

The question of whether corruption harms society or may benefit it is hotly debated by economists. At first, the point of view of the "traditionalists" was

predominant. They believe that corruption has a negative effect on the economy, as it can cause a redistribution of goods that is unfavorable for the society and a reduction in the rate of the economy's development. Then the "revisionists" began to assert that corruption often leads to increased efficiency in resource allocation, which was disrupted as a result of government regulation. As P. Bardhan notes in his survey [23], many studies devoted to corruption assume that, in conditions of numerous ridiculous government restrictions, corruption can promote economic development and increased efficiency.

The reason for this positive effect is that in some cases the presence of corruption demonstrates, for example, that the government has not set prices correctly. So, according to S. Rottenberg [4], a bribe can be considered as a price for the right (or a license) to engage in a certain activity. In some cases, a bribe attributes a positive price to a right the nominal price of which is zero. In other cases, a bribe turns out to be a lower price than the nominal one, which is what happens when a bribe to a government employee is preferable to paying a fine. This raises the question of what the optimum price is for the right to an activity: is it the one that the market shows, or the one that compensates for the full cost of production, or the one that is equal to marginal costs? Can we say that, in some sense, bribery helps to achieve optimum criteria? In some cases, yes.

But, on the other hand, bribery may generate a socially suboptimum price (for example, a bribe to a road inspector instead of a fine increases the probability of accidents and reduces the total utility for drivers [4]).

A similar duality shows up as a result of the conflict between social and personal interests. In a more general case, this problem is formulated for "rent-seeking" behavior [13, 24-35]. This behavior is connected with corruption behavior, insofar as bribery is one of the "trump cards" in competition for rent, along with real resources; however, society's losses or profit from such behavior can be debated (see G. Tullock's article [24]). The dilemma at the center of these arguments is, on the one hand, who can "find rent" better than a person himself (any other way may lead to totalitarianism—"not you, but I, know what is best for you"). But, on the other hand, achieving the social optimum may increase the utility for every member of society.

At present, in our view, the discussion about the positive and negative aspects of corruption has come up with the following point of view, which is supported by many researchers. Differences of opinion about the utility of corruption can arise only in specific cases. Corruption may help economic development in some transitional stage (as is noted in [23], in a number of countries corruption becomes widespread during the process of modernization and development before it begins to decrease), but lingering in this stage may prove to be ruinous for the society (see S.N.S. Cheung's study of corrup-

tion in China [15]). Corruption that has taken root, penetrated society from top to bottom, and become systemic is obviously accompanied by adverse consequences (see M. Johnston's article [17]).

According to P. Mauro [36], corruption has the following consequences, which are confirmed by empirical data:

- a reduction in investment in production and a slowdown of economic growth;
- inefficient use of strengths (talent): instead of producing material goods, individuals spend time on unproductive rent-seeking;
- a reduction in the efficiency of international aid provided to developing countries, as a result of its use for purposes other than those intended;
- tax losses, when corruption takes the form of illegal use of power by tax inspectors;
- a lower quality of public service; and
- the inefficient allocation of government expenditures.

Moreover, as O. Kurer notes [37], although revisionists contend that corruption often leads to more efficient resource allocation, in a clientele political system (which is what a real political system is, to one degree or another), on the contrary, corruption only leads to a significant additional deviation from efficient resource allocation. This happens because corruption leads to political actions that are specially aimed at extracting corrupt profits. For example, a license system may be created for the purpose of maximizing the amount of bribes that bureaucrats receive, rather than maximizing the welfare of society. G. Tullock [38] also pays attention to such a shifting of purposes. He notes the long history of official "buying" of politicians and of decisions on the part of interested groups and proposes that we study the possibility of introducing a market procedure into the operative methods of government decision making, suggesting that the consequences of this might be more efficient than the consequences of the illegal (corrupt) activity that presently exists and that essentially profanes the analogous market procedure.

Corruption is not only connected with redistribution of resources: in the article by L. Hillman [and F. Katz] [13], it is shown that what happens as a result of the competition for a bribe is not simply redistribution of goods but also a waste of additional resources spent on the competition.

Even though F.T. Lui [39] shows that in individual cases corruption may raise social economic efficiency, because bureaucrats will try to accelerate the drawn-out administrative process in order to receive a larger bribe, this does not attest to the real efficiency of such a situation. Rather, it says that "a live dog is better than a dead lion," that is, if bureaucrats do not do anything without a bribe, then it is very good if they do at least something for a bribe.

1.5. *Morality and corruption*

Speaking of the ethical side of the question, we will note that, on the whole, society has always considered corruption to be "amoral behavior." In M. Reder's opinion [40], recognizing behavior as corrupt already subjects it to moral condemnation. The direct economic consequence of this is a lower assessment of the utility of any contact (pursuing gain) with an amoral individual. This occurs partly from the danger of being subjected to joint sanctions, and partly due to the natural aversion to amorality.

E. Banfield [9], who investigated corruption from the point of view of maximization of utility for an economic agent, takes into account the influence of the moral climate on reducing the utility of corruption for the agent. In S. Rose-Ackerman's study [3], the model of the utility function for the participants in a corrupt deal includes the amount of the moral costs from taking and giving bribes. Inclusion of the concept of collective reputation in the modeling of corruption (J. Tirole's paper [41]) also reflects an ethical assessment of this phenomenon on the part of society. One of the conclusions in [41] is that systematically repeated violations of the law may become a tradition that is very hard to fight. By the way, as follows from [42], it is difficult to overcome any traditional behavior in society.

1.6. *Measures to combat corruption*

The current economic approach to studying crime and punishment looks at the maximization of social return as a criterion for formulating optimum laws. If this approach is strictly followed, then, under certain assumptions, we do not need to eliminate corruption completely. It is sufficient just to reach some "optimum" level, because the expenditures on rooting it out may exceed the gain. Various schemes of restriction can be used to reach the "optimum" level of corruption.

One way of investigating measures to combat corruption is to put together a plan for conducting special measures. R. Klitgaard [7] describes a plan of action in this field that was successfully used to combat corruption in the Philippines in 1975.

Principal-agent-client model. The analysis is based on the principal-agent-client model, in which the *agent*, who is a public employee (i.e., a bureaucrat, official, or politician) compares his gain from performing a corrupt act with the costs and maximizes his gain. A similar analysis can be carried out in relation to the *client*, who offers a bribe to the agent. The uncorrupted *principal* considers the balance between the profits from decreasing corruption activity and the price of taking various steps to decrease corruption. The

relationship of these two "prices" is the principal-agent-client model.

The methods the principal can use to control corruption can be grouped in five categories: (1) the selection of agents (and training of them); (2) the changing of incentives (rewards and punishments) that the agents and clients have; (3) the collection and processing of information on efforts made by the agents and clients and their results; (4) the restructuring of the agent-client relationship (for example, decreasing monopoly power, clarifying the rules and procedure to restrict the agent's authority, changing the decision-making rules, and genuinely redefining the organization's mission); and (5) the raising of the moral costs of corruption (for example, with the help of a code of ethics and changes in the organizational culture).

Anti-corruption measures at the organizational, legislative, and executive levels are suggested in [6, 17].

2. Basic approaches to the modeling of corruption

The study of corruption is fairly closely linked with the study of the rent-seeking activity mentioned above, which is the "parent" field, so to speak. Economic investigations of the phenomenon of corruption as such began no later than 1975 with the work of S. Rose-Ackerman [3], which considered corruption as economic behavior in conditions of the risk associated with perpetrating a crime and the possible punishment for it (the foundation for the economic approach to crime and punishment is G. Becker's work [43]). These studies touch upon such questions as "corruption," why it occurs and exists, corruption and the structure of society, ways of combating corruption, the economic role of corruption (profit and loss), the influence of morality, and the developmental dynamics of corruption. In some studies, cases of corruption were described and some statistics were given. In most of them, mathematical models describing how corruption functions were suggested.

2.1. Classification of directions of corruption research

In the literature at present there are a large number of mathematical models of corruption. The most diverse questions related to corruption are studied from different perspectives within the framework of these models. First of all, we can arbitrarily distinguish two directions of mathematical models: the study of acts of external corruption and the corruption of an organization from within (see the grouping in section 1.1). The boundary of the research can be traced fairly clearly here. A third direction deals with observable phenomena such as the nonuniqueness of equilibrium states of corruption, the cyclic nature of

its occurrence, and so forth. Moreover, there are studies on the effect of corruption in certain specific situations.

To arbitrarily classify the directions of research, we will use the principal-agent-client model of which we spoke in section 1.6.

1. The analysis may focus on the agent-client relationship, that is, on the game between them. It is obvious that such analysis deals with the problem of external corruption. This includes the problem of the mutual influence of competition and corruption, the problem of improper resource allocation, and also the question of the principal's influence (for example, that of a politician when the principal is the government) on the game's state of equilibrium.

In our survey, in section 3, we examine the basic study by S. Rose-Ackerman [3], which analyzes corruption in the presence of one bureaucrat (the agent) and firms (clients) competing for a government contract, and the study by A. Shleifer and R.W. Vishny [2], which deals with problems of the allocation of government resources by bureaucrats and the effect of competition between bureaucrats (agents), as well as between clients, on the level of bribes.

Models of corruption in tax agencies can be placed in this category, for example, the models suggested by P. Chander and L. Wilde [44], by A.A. Vasin and O. Agapova [45], and by T. Besley and J. McLaren [46].

Within the scope of this direction, we will briefly mention the work of D. Acemolgu and T. Verdier [12], M. Beenstock [47], C. Bliss and R.D. Tella [48], D.D. Lien [49], F.T. Lui [39], K.M. Murphy, A. Shleifer, and R.W. Vishny [25], D. Mookherjee and I.P. Png [10], and A. Lambert-Mogiliansky [50, pp. 101-38].

2. The analysis may concentrate on the principal-agent problem, including the creation of a "unified control structure," which implies the development of incentives, an information system, decision-making rules, a hierarchical structure, and supervision. We will note that, although the first direction we distinguished also studies ways in which the principal can supervise and influence the agent, studies in the second direction give this aspect greater emphasis: the principal sets the rules of the game not for one agent, but for a group of agents (organized as a hierarchy). This includes the problem of eliminating internal corruption in a hierarchical organization. In this case, the principal either wants to optimize corruption, if his goal is to maximize profit, or to eliminate it entirely, which is what a generalized principal, the government, for example, tries to achieve. Internal corruption appears when the agent in a principal-agent pair is understood to be a group (hierarchy) of agents in asymmetrical relationships. So, for example, the problem of principal-supervisor-agent relationships arises, in which the supervisor is an agent who checks the work of a first-level agent, and the like. In such a hierarchy, if it becomes a "mafia-type" organization, bribes are distributed and handed over from agents at lower levels to agents at higher levels.

We put the work of L. Hillman and F. Katz [13] in this category. They studied the problem of the generation of social costs caused by the dispersion of a bribe in a principal-agent-agent- . . . -agent-client chain as a result of competition around the client's position and each agent's position. In this case, the government can be considered the principal, who tries to minimize social costs. This direction includes the work of F. Kofman and J. Lawaree [51], which is devoted to the principal-supervisor-agent problem, and the work of M. Bec [5], which develops this theme. In his model, various types of hierarchies are investigated in place of the agent. We can also include in this direction the work of K. Basu, S. Bhattacharya, and A. Mishra [52], A. Lambert-Mogiliansky [50, pp. 52–101], A.P. Mikhailov [53], T.E. Olsen and G. Torsvik [54], and J. Hindriks, M. Keen, and A. Muthoo [55].

3. The analysis may concentrate on studying transition processes in a corrupt system, steady states of the system, their stability, and also such phenomena as cycles and reactions to external shocks, for example, anti-corruption campaigns. The models that we include in this direction are dynamic ones (however, we will note that this trait will not be decisive; dynamic models are considered in other directions of research) and can be either "microeconomic" or "macroeconomic."

F.T. Lui's model [22] illustrates situations in which economies with identical parameters have different levels of corruption. The work of G. Feichtinger and F. Wirl models the phenomenon of cyclic political corruption on the macroeconomic level: the replacement of phases of combating corruption by periods of silent encouragement of it. J. Tirole [14] analyzed the significance of collective reputation and its historical aspect. In the work of C. Bicchieri and C. Rovelli [56], it is shown that the evolution of corruption in an economy may spontaneously lead to an explosion—a "revolution of honesty," as a result of which the system moves to a new state.

The work of J. Andvig and K. Moene [57], A. Antoci and P.L. Sacco [58], C.M. Aslis and V.H. Juan-Ramon [59], and O. Cadot [60] can be included in this category.

4. We will also note studies that investigate some specific questions concerning corruption.

Using game-theoretic analysis, R.B. Myerson [61] investigated various voting systems in relation to their comparative effectiveness in reducing corruption in the government. The conclusion of this research was that majority voting will be only partly effective, in the sense that there is always some equilibrium in which members of the "corrupted" parties are eliminated from the government. Borda voting is ineffective because in some political situations there is no guarantee that members of the "corrupted" party will not be included in the government. (The modeling of political and economic corrup-

tion was also the subject of the article by L. Dudley and C. Montmarquette [62], which looks at different types of fiscal systems, and articles by E. Rasmusen and J.M. Ramseyer [63], and A. Shleifer and R.W. Vishny [64].

M.R. Gupta and S. Chaudhuri [65] investigated the question of extension of formal and informal credit to a farmer by a government bureaucrat (to whom a bribe must be paid) and a loan shark, respectively. The credits can preclude or supplement each other. The government bureaucrat and the loan shark play simultaneously, not cooperating with each other, but choosing the "bribe rate" and the interest rate for informal credit, respectively. States of equilibrium are studied in this game. One of the results of the investigation is the fact that in equilibrium the interest rate for informal credit and the effective formal interest rate (including the bribe) are equal, which can sometimes explain the exorbitantly high interest rate for informal credits by the specific nature of a government farm-subsidy program.

2.2. Classification of mathematical models of corruption according to certain characteristics

On the basis of the grouping (in the preceding section) of research directions, we can classify mathematical models of corruption according to certain traits: taking into account the presence of a principal, agent, client, dynamics, and so forth.

In Table 1, the models are assigned traits that can be present ("+") or absent. The notations are as follows: *P*—the presence of a principal is modeled, *EX*—exogenously, *M*—profit is maximized by the principal, *PPP*—there is competition among principals, for example, employers, *A*—the agent maximizes his profit, *[AAA]*—competition for the agent's place, *AAA*—competition among agents, *A-A*—with a hierarchy of agents, *C*—the client maximizes his profit, *[CCC]*—competition for the client's place, *CCC*—competition among clients, *D*—dynamics is present, *H*—morality is taken into account, in other words, honesty and reputation.

The maximization of profit simultaneously by the principal and the agent ($X = M, A$) creates the principal-agent problem; the maximization of profit simultaneously by the agent and the client (A, C) produces a game of the agent and the client. Competition traits (*[CCC]*, *CCC*, *[AAA]*, *AAA*) were defined as characteristic, insofar as this is almost the most important characteristic of the service market in general, as well as the market for corrupt services in particular [2, 73]. Competition for the agent's place (*[AAA]*) means, for example, that the bureaucrat's place is sold, that is, competitors vie to receive this "cushy job." Competition for the client's place (*[CCC]*) means that the product sold to the client by the agent is the only one of its kind, for example,

Table 1

Classification of Some Mathematical Models of Corruption by Traits

	P	A	[AAA]	AAA	A-A	C	[CCQ]	CCC	D	H
S. Rose-Ackerman	RX	+				+	+			+
M. Bac	M	+			+					
F.T. Lui	EX	+							+	+
C. Bicchieri and C. Rovelli	EX	+		+		+	+		+	+
G. Feichtinger and F. Wirl	+							+	+	
P. Chander and L. Wilde										
J. Tirole	PPP	+		+					+	+
A. Shleifer and R.W. Vishny	+	+		+	+		+			
L. Hillman and F. Katz	M	+		+		+	+			

Sources: S. Rose-Ackerman, "The Economics of Corruption," *Journal of Political Economy*, no. 4, 1975; M. Bac, "Corruption and Supervision Costs in Hierarchies," *Journal of Comparative Economics*, no. 22, 1996; F.T. Lui, "A Dynamic Model of Corruption Deterrence," *Journal of Political Economy*, no. 31, 1996; C. Bicchieri and C. Rovelli, "Evolution and Revolution. The Dynamic of Corruption," *Rationality and Society*, vol. 7, no. 2, 1995; G. Feichtinger and F. Wirl, "On the Stability and Potential Cyclicity of Corruption in Governments Subject to Popularity Constraints," *Mathematical Social Sciences*, no. 28, 1994; P. Chander and L. Wilde, "Corruption in Tax Administration," *Journal of Political Economy*, no. 49, 1992; J. Tirole, "A Theory of Collective Reputations," *Research Papers in Economics* (University of Stockholm), no. 9, 1993; A. Shleifer and R.W. Vishny, "Corruption," *Quarterly Journal of Economics*, vol. 107, no. 33, 1993; L. Hillman and F. Katz, "Hierarchical Structure and the Social Costs of Bribes and Transfers," *Journal of Political Economy*, no. 34, 1987.

some large government order that is given out only by that specific agent. Competition among agents (AAA) means that the good is made available by more than one agent, for example, in the department that issues visas there are many bureaucrats, and a visa can be obtained from any one of them. Competition among clients (CCC) can mean, for example, that each company tries to obtain some favorable treatment for its business, because otherwise its competitors earn more than it does.

2.3. Difficulties in modeling corruption

We must note that, because corruption is an illegal activity, the statistical data on its scale and manifestations, rules operating within the corrupt community, and on the mechanisms by which it operates are very hard to determine. This makes it hard to study, and, in particular, to model. For example, contracts about the amounts of bribes and the services rendered in exchange for them are rarely written down. Numerous studies on the Sicilian and other mafias read like judicial reports or works of literature, rather than clear institutional or economic analysis. We will only point out some statistical and economic studies that have appeared recently (for example, [66]).

3. Basic model of corruption and some variations of it

In this section, we will examine the basic studies in which the ideas about a market for corruption services are formulated.

3.1. Models of a corruption economy

We will begin with S. Rose-Ackerman's pioneering work [3], which considers the competition of "external" companies (clients) in relation to a government organization to receive a contract or rent. Such a contract is acquired with the help of a bribe that is paid to a government bureaucrat (agent) by the clients competing among themselves or by one of them. In other words, in this model, each client (company) tries to buy off the bureaucrat for the purpose of receiving a government contract. It is assumed that the bureaucrat can be punished for taking a bribe, and that he suffers materially and morally. The situation of the company paying the bribe is analogous. The model that emerges in this situation is a typical model of rent-seeking behavior, on the condition that competition occurs only between the companies; the bureaucrat acts as a monopolist. It is assumed that the government wants to acquire some good in the market that can be delivered by one of the competing companies. These

companies deliver goods that may differ in quality and price. The following specific cases are considered.

1. The government's preferences in relation to the good are precisely formulated, and a number of companies compete with each other to get the contract. In this case, it is possible that:

- the product is the same from all of the companies;
- the product differs.

2. The government's preferences are not precisely formulated, and a number of companies compete with each other to get the contract.

3. The government's preferences are not precisely formulated, and only one company wants to receive the contract (a case of dual monopoly).

The subjects of investigation are the conditions (including how private markets are organized and the structure of government programs) in which an illegal deal will be made, that is, the contract will be received "for a bribe," and what the amount of that bribe will be if certain assumptions are made about the participants' behavior and the conditions under which the contracts are given out.

Brief description of the model. 1. We will consider a model of an illegal deal in situation 1. We will note that in the case of identical goods it is easy to tell if the bureaucrat deviates in any way from the socially useful decision. First of all, if there is a private market, then it makes no sense for the companies to bribe the bureaucrat, since they can sell the good in the market. If there is no private market, then in this case corruption can be easily eliminated, for example, by using sealed bids, so that the company that is willing to sell the good at the lowest price "wins." If the goods differ and the savings on the contract will be significant, or if the good is not sold in the private market, then the companies do have a motive to buy off the bureaucrat. We will note that, in this case, all of the companies offer the bureaucrat a choice of goods that are the same from the point of view of the combination of price and quality, because they will all try to stay in line with the dominant seller. Consequently, the bureaucrat can choose any of the competitors, because any decision from the entire range of price and quality has the same utility for the government. In this situation, the companies may try to get the contract with the help of a bribe. It is assumed that the bureaucrat organizes the market for bribes, truthfully informing each company about the largest amount already offered.

Let G be the bureaucrat's profit, and π_i be the profit of the seller i , then

$$G(X^i) = X^i - J(X^i) - R(X^i), \quad (1)$$

$$\pi_i(X^i) = P^i q - T^i - X^i - D^i(X^i) - N^i(X^i), \quad (2)$$

where X^i is the total amount of the bribe paid by the seller i ; P^i is the price of

a unit of the seller i 's product; q is the amount of the product that the government needs (it is assumed that this quantity is assigned); $J(X')$ is the average penalty for the bureaucrat, $J' \geq 0$; $R(X')$ is the moral cost of taking a bribe X' for the bureaucrat in terms of money, $R' \geq 0$; T' is the total cost of producing q units for the seller i ; $D'(X')$ is the average penalty for the seller, $D' \geq 0$; and $N(X')$ is the moral cost of giving a bribe X' for the seller in terms of money, $N' \geq 0$.

The quantity $J(X')$, which reflects the expected penalty for the bureaucrat, can be determined by multiplying the average penalty charged if he is convicted times the combined probability of arrest and conviction. A similar procedure can be used to determine the expected penalty for the seller $D'(X')$.

The set of bribes X' that is acceptable for both the bureaucrat and the selling companies is picked out in terms of the bureaucrat's and the seller's profit. The optimum (in one sense or another) point (or amount) of the bribe can be selected in this region.

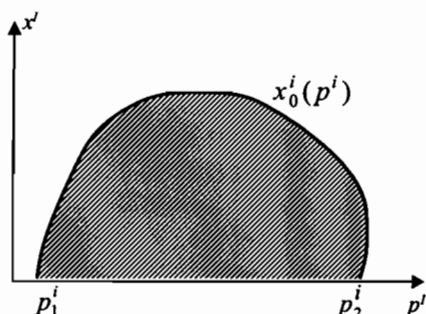
For the bureaucrat, all bribes $X \geq J(X) + R(X)$ are acceptable. Four possible cases are considered: (1) there is no acceptable bribe; (2) all bribes are acceptable because, for example, $J' + R' < 1$ and $J(0) + R(0) = 0$; (3) all bribes no more than some maximum level are acceptable, because the marginal moral costs and/or the marginal expected penalties increase with an increase in X ; (4) bribes greater than or equal to some minimum are acceptable because $(J_{xx} + R_{xx}) \leq 0$ and $J(0) + R(0) \geq 0$. The most plausible is case 4, in which all bribes greater than or equal to some level X_{\min} are taken.

The acceptable region for the seller i is determined by the relationship $X' \leq P^i q - T^i - D^i(X') - N^i(X')$. Thus, in order for a bribe to be possible the condition $P^i q - T^i > 0$ must be fulfilled. This means that, unless every company in the market is corrupt, a potentially corrupt company should earn a surplus profit, either because it operates more efficiently than a marginally efficient company, or due to the "entry barrier" to the market, which benefits all of the selling companies. For each seller i , we can find the maximum possible bribe that it is capable of giving. If, then company m gets the contract. That is the rule according to which the bureaucrat chooses the winning company.

If we assume that the expected penalties will be the same for all of the companies, then the winning company will be the one that has the greatest difference between its income and the sum of production and moral costs in the case of a bribe. Since the production and moral costs are considered similarly, the amount of the maximum bribe that a company is willing to pay may go down either because production costs rise, or because more scrupulous people become the company's representatives.

2. In the situation with imprecisely formulated government preferences, the model is complicated by the introduction of one more parameter: Y' —the

Figure 1. Possible Shape of the Region of Acceptable Values of Bribes for a Company



level of quality. A price rise or reduction in the quality of the product simply increases the probability of punishment for the participants in the deal. It is assumed that

$$J = J(P^i, Y^i, X^i), J_p \geq 0, J_y \leq 0, J_x \geq 0, J(0, Y^i, X^i) = 0, \quad (3)$$

$$D = D(P^i, Y^i, X^i), D_p \geq 0, D_y \leq 0, D_x \geq 0, D(0, Y^i, X^i) = 0. \quad (4)$$

Now it is possible that the companies want to give bribes even if they have no surplus profit, because the higher prices that they get can exceed the additional moral costs and the costs from punishment. If we assume that each company i delivers a product of certain quality Y^i and that each company can vary P^i , then the acceptable set for each company includes the amounts of bribes with which the total "profit" is greater than or equal to zero:

$$0 \leq P^i q - T - X^i - D^i(P^i, Y^i, X^i) - N^i(X^i). \quad (5)$$

The function in Figure 1 represents the combination of price and a bribe that produces zero profit for each company, and the hatched area represents one possible form of the acceptable set of bribes. For each seller i , the maximum possible bribe is , at which the profit is equal to zero. In a situation of competition, when the companies act independently of each other, the winning company can be determined with the help of the following three-step procedure: first determine the functions , then determine the combinations of price and quality that maximize the bureaucrat's profit $G^i = X_i - J(P^i, Y^i, X^i) - R(X^i)$ on the condition that the company's profit is equal to zero, and finally the bureaucrat chooses the company that maximizes his profit G_{\max} .

3. Next we will consider various cases of the penalty functions for both the companies and the bureaucrat. The effect of institutional conditions on the existence and scale of corruption is studied in terms of these functions, as is the case of dual monopoly, which we will not give in detail.

It is noted in [3] that, because the companies that do not win the contract may report a bribe to the authorities, it is in the interests of the winning

company to share the profit from the contract with its unsuccessful competitors and possibly to share the material costs of supporting corruption with them. In the final analysis, this leads to the replacement of competition by collusion—the formation of a cartel of former competitors, and actual competition is replaced by a dual monopoly.

Basic conclusions. The model under consideration apparently makes it possible, for the first time, to clearly formulate a number of basic problems that come up in describing corrupt behavior. First of all, what kind of market is there for corruption goods—monopolistic, oligopolistic, or fairly competitive on the part of the companies? The model permits obvious generalizations for the case of several participants on both sides and the study of states of equilibrium in such a “corruption economy” within the framework of Nash or Stackelberg equilibria. Second, what are the costs for the participants in such a deal, are they material or moral, what determines the amount of them, and how are they related to the institutional system—legislative, the norms of society, traditions, and the like? These questions have to be studied in order to investigate the effectiveness of measures to combat corruption. Third, what are the social costs in connection with corruption and how can they be decreased? This question is not explicitly formulated; it is assumed that the less corruption, the better. The concept of the level of corruption is also not formulated. Fourth, the model touches upon the question of the dynamic aspects of corruption. In this case, the author limits herself to mentioning the short-term and long-term consequences of anti-corruption campaigns.

The model allows us to draw a number of qualitative conclusions. Corruption is not simply a function of the sum of resources spent on supervision and prosecution; it depends on the structure of relations between the government and the private sector. These relations may encourage the corruption of behavior or restrict it. Thus, if the government purchases a good that is also sold in the private market, there is much less motive for bribery than when the government is the only buyer. When goods are specially ordered by the government for public use, measures have to be developed for making the instructions and requirements clearer, which will make it possible to reduce the cost of effective supervision of the proper choice of a contractor and increase the probability of exposing cases of corruption. Another way to combat corruption (in the opinion of the author of [3]) is to create a state company that has to fill a vaguely formulated order.

In turn, it follows from the model that effective punishment for corrupt activity cannot always be achieved by simply imposing heavy penalties on the participants in illegal deals, depending, for example, on the amount of the bribe. The question of whether or not the penalty should also depend on the company's profit, the probability of discovering a violation of the laws,

and on how well the requirements are formulated in the order needs to be investigated.

The model also shows that potentially corrupt companies have to be more efficient than those that maximize profit in an uncorrupt economy in order to be able to pay a high enough bribe. What is more, in order to win out over its competitors, a company has to have a number of specific features. It has to reduce its moral costs and intensify its political influence, making severe punishment less likely and at the same time decreasing the probability of discovery of its participation in corrupt activity.

M. Beenstock [47] continues the microeconomic investigation of corruption that was begun by S. Rose-Ackerman, and his model of corruption takes into account variations in the probability of discovery of an illegal deal and variations in the amount of the penalty. The article also discusses the economic effect of corruption and draws the conclusion that the effect is most often unfavorable, though exceptions are sometimes possible.

The article by D. Mookherjee and I.P. Png [10] also looks at a game with two participants and the impact of government measures on this game's state of equilibrium. The participants in the game are a company (the client) that is polluting the environment, and an inspector (the agent) who must report to the government (the principal) on the results of his inspection. The government can change the company's and the inspector's penalty functions for corruption, the inspector's bonus function for revealing pollution, and the company's penalty function for pollution. Several purposes can be achieved in doing so: minimizing its efforts and also minimizing pollution. An interesting result is the fact that only a significant change in the amount of the penalties from the inspector is capable of leading to a decrease in pollution.

A. Lambert-Mogiliansky [50, pp. 101-38] investigates the fulfillment of illegally executed contracts. Since the legal means of guaranteeing the performance of such contracts cannot be put into effect, the question of how this can be done arises. The study suggests the following model: there is a legal business network consisting of a large number of companies, and one bureaucrat with whom the companies can enter into illegal agreements. The fulfillment of such agreements is guaranteed, because the bureaucrat and the companies are connected in a legal network and the network can punish its members. If the company violates an illegal agreement, the bureaucrat boycotts the entire legal network of companies until the violator is expelled from the network. A repeated game occurs between the companies and the bureaucrat, and this leads to the formation of a mechanism that ensures the fulfillment of illegal agreements.

The model suggested by D. Acemolgu and T. Verdier [11] is of special interest. In it, the motives for a client to buy off an agent are internalized. The

model analyzes an economy consisting of agents who are neutral to risk, each of whom can engage in one of two types of activity: business (trade or production) or public. Production takes place in the private business sector, while the public sector is needed to guarantee property rights. The agents of the economy differ in their level of business talent. Production is mediated by contracts between trade businessmen and production businessmen. The guarantor of the property rights of such a contract is a public (government) bureaucrat. The trade businessman (the client, according to the terminology that we introduced) wants to buy off the bureaucrat (agent) in order to increase his profits. The execution of such a deal may entail a reduction in investments in production on the part of the production businessman. The model's state of equilibrium includes some scale of corruption and an index of property rights and investments in production. One of the model's interesting conclusions is that, even if society is optimally organized, there still may be a place in it for rent (inflated salary) for bureaucrats in the public sector, some amount of corruption, and nonoptimum allocation of talents.

The same authors' work [12] within the framework of a somewhat different model proves that all of these consequences (the presence of corrupt bureaucrats, rent in the public sector and not the best allocation of talents, and, moreover, an excessive expansion of the public sector and a rise in the salary level in it) are still not sufficient proof that society must avoid government interference. Such a result is proved on the condition that the government actually tries to correct market imperfections and not simply to benefit itself when it develops regulations.

3.2. Model of resource allocation in an economy with corruption

Problems similar to those considered by S. Rose-Ackerman [3] are investigated within the framework of the model of A. Shleifer and R.W. Vishny [2]: the possibility of "stealing" from the government the goods that a government employee distributes, the role of monopoly and monopsony in the spread of corruption, and the interrelation of the structure of political and economic institutions and the level of corrupt activity. The authors work with the usual tools for microeconomic analysis: marginal productivity, marginal costs, and so forth. The study's basic propositions and conclusions are considered below.

Corruption is defined as the sale of state property by government employees for private purposes.

1. The simplest model is studied, in which the government produces one product (e.g., an import license). The good is considered uniform and there is some demand curve for this good $D(p)$ on the part of private individuals.

Assumptions. Suppose that this good is sold by a bureaucrat who can influence the amount of the good that is sold. It is assumed that he can simply refuse to make the good available. Suppose that the bureaucrat can actually change the supply without any risk of "discovery" or "punishment" from above. (Prosecution of the bureaucrat for corruption changes the level of the bribes that he demands, but it does not change the essence of the problem.)

A. At first, it is assumed that the government employee makes the good available monopolistically and that his purpose is to maximize the amount of the bribes he collects from the sale of this government good. Suppose that the official price for this good is equal to p , and for the bureaucrat there is no cost of producing the good, since the government itself pays these costs. This assumption is fairly important.

What then is the marginal cost MC for the bureaucrat who distributes this good? Two cases are considered. The first one is the absence of stealing; the employee actually turns over to the government the official price of the good. In this case, the MC of providing the good is equal to p for the employee. The second case is the presence of stealing; the bureaucrat does not turn over anything at all to the government, but simply steals what is sold. In this case, the price that the buyer pays is equal to the bribe and may even be lower than the official price. In this case, the MC for the bureaucrat is equal to zero. While the two cases are conceptually identical (they differ only in the level of MC for the bureaucrat), in the first case the total price of the product is always important, while in the second case it may be less than the official price (the bureaucrat may reduce it). It is obvious that corruption with stealing is more attractive for the buyer.

If the bureaucrat cannot engage in price discrimination, then, like an ordinary monopolist, he will simply set the price so that the marginal return is equal to the marginal cost $MR = MC$. Hence, it is easy to obtain equality of bribes and the tax on the good, that is, in the case without stealing, the bribe is exactly equal to the tax on the good that maximizes revenue, when $MC = p$ (the government price).

B. It is noted in [2] that corruption spreads as a consequence of competition among bureaucrats (agents) as well as among consumers (clients). Competition among bureaucrats will lead to a situation in which it is precisely the maximum bribes that will be collected. Even more important for the spread of corruption is competition among consumers (clients) in the case when stealing takes place. If buyer A can buy government services cheaper than buyer B , then he wins the competition against buyer B in the product market. Therefore, if buyer A gives the government employee a bribe to reduce his costs, his competitor is compelled to do the same.

2. If the private agent (client) needs several interrelated government prod-

ucts in order to carry out his own activity and the bureaucrat is not a monopolist in providing these products, then some important effects of corruption arise. Within the framework of the standard microeconomic approach, the model looks like this. Let X_1 and X_2 be the amounts of the products sold. The official prices are equal to the monopolist's marginal costs MC_1 and MC_2 . Then the amounts of the bribes are equal to $p_1(MC_1)$ and $p_2(MC_2)$. The joint monopolistic agency keeps the price p_1 at which

$$MR_1 + MR_2 * dX_1/dX_2 = MC_1, \quad (6)$$

where MR_1 and MR_2 represent the marginal income from sale of products 1 and 2, respectively. When the two products are interrelated, for example, government permits for the same project, then $dX_2/dX_1 > 0$ and $MR_1 < MC_1$ at the optimum point. The monopolistic agency restrains the increase in the amount of bribes for product 1 in order to increase demand for product 2 and thus increase the profit from bribes for product 2.

Now we will assume that independent agents may issue permits 1 and 2. At the optimum point for an independent agent, $MR_1 = MC_1$. Consequently, the bribe from a single product will be higher and the production of the product will be lower than at the optimum point for a joint monopoly. Due to the fact that independent monopolistic agencies ignore the effect of an increase in the amount of the bribes on demand for the interrelated permits, and, consequently the other agency's bribes, the result will be a lower volume of production and average collection of bribes. Acting independently, the two agencies actually harm each other, as well as the private buyer, in issuing permits.

The situation is considerably worse in cases when there is an opportunity to freely join in on the collecting of bribes. Then the total amount of the bribes grows to infinity, and the sale of the government product, as well as the amount of bribes collected, drops to zero.

A third case is possible, when each of the interrelated government products can be offered by two government agencies. In this case, as is easy to see, it will be hard for several agencies to collude with each other and the competition between suppliers for receiving bribes will reduce the level of the bribes themselves to zero.

The level of the bribes will be lowest in the third case, intermediate in the second, and highest in the first. However, the total amount of income from the collection of bribes will be higher in the first case, rather than the second, because the independent monopolists lower the amount of sales so much that the total income from corruption drops. This result is obvious: in the first case the suppliers of interrelated products try to maximize the total amount of bribes collected, while in the second case they do not.

In [2], a great deal of attention is paid to the significant difference between

the activity of an "industrial" organization and an organization that "produces bribes." So, in spite of the outward similarity, bribes differ from taxes in one decisive way, namely, corruption is usually illegal and has to be kept secret, which is the reason for the larger distortion of the efficient resource allocation in the case of corruption than in the case of taxation.

The authors of [2] point out two important reasons why corruption may have a heavy cost on economic development. The first reason is the weakness of the central government, which allows various government agencies and bureaucratic machinery to independently collect bribes from private agents who receive interrelated permits from these agencies.. The second important reason why corruption has a high cost is distortions caused by the need to keep it secret. The need for secrecy may displace investments in the country from the most profitable projects (in public health, education) toward potentially useless projects (defense, infrastructure), if the latter provide better conditions for concealing corruption. Thus, economic and political competition may lower the level of corruption and its adverse consequences.

K. Murphy, A. Shleifer, and R. Vishny use similar ideas in their study [25]. Within the framework of a single-sector model of agriculture, it is shown that corruption consisting in appropriating part of the profit received (in the form of requisitioning of agricultural products or taxation of them) may wipe out the effect from obtaining surplus product and transform the industry from profitable to self-supporting at best, and at worst simply ruin it.

C. Bliss and R. Tella [48] study the fact that there is sometimes a rise in corruption in countries with an increased level of competition in the economy, indicating that a reduction in corruption does not necessarily follow growth of competition. The difficulty of studying the effect of competition on the level of corruption is that competition is not necessarily an exogenous parameter that can be changed in the model to see how it affects the level of corruption. In turn, corruption also influences the level of competition. This article studies the relationship between corruption and competition and suggests a model in which both the equilibrium number of companies and the level of corruption are determined by endogenous parameters of competition.

Among the directions of research on the positive role of corruption in eliminating the consequences of nonmarket resource allocation are studies modeling the effect of bribery on resource allocation with the help of queues. Here we will point out the work of F. Lui [39] (who developed the similar, earlier work of L. Kleinrock [67]), in which a model of resource allocation with a queuing mechanism is proposed. The time spent unproductively on waiting in line can be reduced by buying the right to bypass the line for a bribe. The larger the bribe is, the less the waiting time will be. This study shows that such a mechanism, which is largely identical to the mechanism of "shadow prices,"

may lead to an increase in the efficiency of allocation. At the same time, the question of whether or not this conclusion can be extended to models of general equilibrium with nonequilibrium prices, quotas, and queues has not been studied yet. Apparently, this is a promising direction for investigating the efficiency of an economy with corruption.

The problem of resource allocation was also considered by D. Lien [49], whose model studies the possible defects of allocation connected with corrupt activity. In this study, it was shown that, if certain additional assumptions are made, the probability of defects in resource allocation increases with a rise in the degree of discrimination against one client in favor of another by the bureaucrat (for example, thanks to friendly relations with the first client).

4. Conclusion

The market for corruption goods, of which we spoke previously, can be represented within the framework of models of economic equilibrium with two types of prices, and, accordingly, two markets: "white" and "black." Goods that are traded in both markets are the objects of corrupt deals (licenses, taxes, etc.). In the first market, the "white" one, which is legal, the prices are fixed and the goods will be in short supply. In the second, "black," shadow market, the same goods are distributed at "market" prices "according to the law of supply and demand," which determines the amount of the "price," that is, the bribe. The shadowy nature of the second market predetermines the possibility of punishment for the participants who make deals in this market.

The scarcity of the goods is due to ordinary economic matching mechanisms with inflexible prices: quotas, queues, and the lack of information and the time to acquire it. These mechanisms may be the natural consequences of regulation of such an economy, or artificially created by those who benefit from the existence of the second, shadow market. The number of participants in such an economic system, the types of corruption goods, and the rules of the game may change with time, exogenously or endogenously. In such an economy, competition can be monopolistic, oligopolistic, or even perfect. The model of the economy can be determinate or stochastic, static or dynamic; and the corruption goods can be discrete or divisible. It is precisely such an approach that makes it possible to use the tools of general equilibrium theory, and, in particular, to investigate questions of equilibria in such an economy, their efficiency, and also the comparative dynamics with different exogenous parameters determining, in particular, the punishment for participants in the shadow market. In our view, developing such models of corruption markets will make it possible to move from numerous and rather fragmentary models of corruption to a generalizing theory of corruption as a major economic phenomenon.

The investigation of a corruption economy should include the following as well:

- the collection, processing, and analysis of statistical data on the types of corruption activity, fields of corruption activity, measures to combat it, and their actual effectiveness;
- the study of the possibility of replacing corrupt acts by contracts that are normal from the economic and legal point of view;
- the development of economic institutions and rules fostering a reduction in corrupt activity and a decrease in the probability of its spreading; and
- the study and adoption of measures to reduce the corruption of politicians responsible for legislation in the field of the economy and management of government activity.

The analysis of corruption as a socioeconomic and political phenomenon could be based on a system of indexes—the characteristics of various parties to corrupt activity. A classification of corrupt deals can be created on the basis of these indexes. Here is an example of such a system, which seems suitable to us.

1. Characteristics of corrupt actions

- 1.1. Direct-mediated
- 1.2. Active-potential
- 1.3. Isolated act-regular, systematic activity
- 1.4. Money-grubbing-extortion

2. Subject of corruption and type of payment

- 2.1. Economic goods-political goods
- 2.2. Type of payment for corruption services

3. Characteristics of participants in corrupt deals

- 3.1. Low-level-top-level corruption
- 3.2. Corruption in the interests of a single participant-corruption in the interests of a group
- 3.3. Corruption perpetrated by individuals-corruption perpetrated by an organization specially created for that purpose
 - 3.3.1. Giving bribes
 - 3.3.2. Receiving bribes

4. Causes of the appearance of opportunities for corruption

- 4.1. Artificially created situation for extortion-natural situation
- 4.2. Degree of conflict between legal standards and the condition of society
- 4.3. Degree of imperfection of the law, regulatory acts, and the like (not well thought out, no consideration given to future consequences)

5. Consequences of corruption

- 5.1. Easy to detect—hard to detect
- 5.2. Easy to punish—hard to punish
- 5.3. Type of punishment
- 5.4. Level of danger for society
- 5.5. Positive effect from corruption—negative effect (from the standpoint of a higher level of social criteria)

6. Type of society in which corruption is perpetrated

- 6.1. How traditional corruption is for a given society
- 6.2. Historical roots of corruption in a given society
- 6.3. Type of economic system in which a corrupt deal is perpetrated
- 6.4. Type of political system in which a corrupt deal is perpetrated.

These indexes can be used to analyze specific cases of the appearance of corruption, and, apparently, fairly general models of corrupt relations can be constructed with their help. However, as a rule, only individual, typical, common corrupt deals are the subject of modeling at present.

Factual data on the current state of corruption in a number of countries, including Russia, and measures to combat corruption, and also discussions of political problems caused by corruption can be found in the report by M.I. Levin, G.A. Satarov, and M.L. Tsirik [68], and in the article by M.I. Levin and G.I. Satarov [19].

At the same time, corruption should become a subject not only of economic but also of sociological, psychological, and political-science analysis. Historical facts scattered through the literature on corruption indicate that it is, if not as old as the world, then as old as authority. A well-known quote from Lord Acton is mentioned in [8]: "Power tends to corrupt and absolute power corrupts absolutely," and it is noted that democracy as such does not seem to be a sufficient guarantee against bribery. In fact, no one has escaped "the lot of corruption." The literature gives numerous facts of corrupt activity in developing countries (Latin America, countries of Southwest Asia, India, etc.), and also in developed countries such as Italy, Spain, Germany, and France. There are numerous sources on corruption and the periodic struggle against it in China (see [8]).

Information on corruption in prerevolutionary Russia can be found in the classical literature known all over the world (see Gogol, Sukhovo-Kobylin, Saltykov-Shchedrin, and Chekhov), and in [1] and [18]; on corruption in the USSR, in A. Kirpichnikov's book [18], and also from V.I. Lenin's instructions of May 1918, F.E. Dzerzhinskii's proposals (1923), the notes of the Department of Administrative Agencies of the Central Committee of the Communist Party of

the Soviet Union and the Party Control Committee under the Central Committee (May 21, 1981); and on corruption in post-Soviet Russia, from the messages of the president of the Russian Federation (1997–98) to the Federal Assembly.

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