MARK LEVIN

Diffusion of Technological Innovations with Violation of Property Rights (Intellectual Property Rights and Corruption)

1. Introduction

One of the main issues of innovation on the firms' level is a diffusion (transfer) of new technology from one firm to another one. The transfer of technology depends on agreements between firms and depends on the laws concerning intellectual property rights (IPR) [2,5,10]. The typical situation is: a firm with high level of technology may transfer (sell) its technology to a firm with a low level of technology. The latter pays royalties and/or license. Levels of royalty, license, and technology itself depend on the agreement between the firms. The type of agreement depends on institutional environment, competition and, of course, on laws enforcing IPR [6,13]. Violation of IPR often takes place in situations where there are no well-defined contract laws and violations of IPR are not strongly prevented. Such a situation is typical for the transitional economies, and could be one of main problems for the diffusion of innovations from high-developed firms (usually foreign ones) to the domestic less-developed firms. Some papers on analysis of consequences of the IPR violation at the firms' level had been published recently: see, for example, [3,4].

Such violation of IPR may take place as a result of corruption that is one of the main feature of the countries with transitional economies as former socialistic countries like Russian Federation [7,8,11] and developing countries [1,9].

This paper contains models for analysis and evaluations of corruption influence in the field of technology transfer from one firm to another one.

We present simple economic models in which corruption arises in framework of technology transfer from technologically developed firms to technologically less developed ones. In the literature the first type is named 'North', and the latter one 'South', and the problem of diffusion of innovations from North to South is named 'North-South technology transfers problem'.

This problem is a very important framework for studying transition economy because an important factor of transition post-socialist countries to developed market economy is an essential modernization of their technological base by borrowing the leading technologies from advanced countries.

Let us recall the problem. On the North, there are firms producing new knowledge and ideas. On the South, there are developing firms who have old technologies. The North can transfer a new technology to the South on a certain conditions. It may be legally conditions or not. The technology has been produced on the North that spends human and material resources. On the other hand, having been the new technology without any waste for producing, the South gets a rent and is able to compete with the North. Therefore, industrially advanced firms build up natural rivals by transferring new technology. Protection of intellectual property rights (patents, license and etc.) is aimed at indemnity of the rent obtaining by Southern firms at the expense of Northern firms. Following problems occur here:

1. Is it profitable to produce new knowledge and technological research and development (R&D) on the assumption of pirating the innovation technology?
2. When the transferring of new technology is profitable? What are conditions of the transferring?
3. When the effective transferring occurs? What is conditions of the effective transferring: a) from the Northern firm's point of view? b) from the Southern firm's point of view? c) from the whole economy system's point of view? Note that demonopolization, generally, is profitable for society because it decreases prices and increases overall production. On the other hand, the demonopolization (we mean pirating) can result in decreasing or destruction incentives to invest capital into innovation process. In other words, it is necessary to keep a certain "balance of interests" up between building competitive environment and keeping incentives to produce new knowledge and ideas. The balance of interests can keep up either by legal way for instance it may be prohibition to technological transfer, or the sale of technology, e.g. licensing etc., or illegal way: it may be pirating or graft official who is legally bound to protect intellectual property rights. In practice corrupt officials are found very often. Furthermore, since corruption contraries to law, and is shadow activity, it is possible that bought

technology is not the best one. And what is more, even if the Southern firm pays for the best technology in low this is likely to get "middling" technology provided that officials are corrupted.

There is another problem arising at technological transfer. This is competition either among Southern firms for purchasing advanced technology or among Northern firms for technological transfer on profitable conditions. There are quite enough opportunities for corruption, since technological transfer and introduction of the technology to production as well as efficiency of technology are the completely different things: it is possible to purchase the most efficient technology and introduce it ineffectively alleging initial "poor quality" of technology. On the contrary, it is possible to transfer middling technology but explain inefficiency by unsuccessful introduction. It is a good field for corruption because of opacity. As we know, study of corrupt behavior in such environment has never been carried out, though we believe this is an urgent point. First, the study makes possible to describe areas when corruption can arise i.e. corrupt behavior can be profitable for agents. Second, the study allows stating the value of economical waste from the corruption, maybe on qualitative level. In this chapter we present a kind of such analysis. We consider linear models in order to simplify an analysis.

In the part 2 we introduce the model of economic system which is the basic model for our analysis for technological transformation. In the part 3 we consider a case where transferable technology is licensed but corruption prevents transformation of the best technology.

Let us note that corruption is only one of institutional failures of R&D processes at the firm level. Nevertheless, the analysis of the consequences of such phenomena is very important for understanding why technological progress in transitional and less-developed countries is not so successful as it would be possible to expect.

2. Basic model "innovator - imitator"

We present a model that includes two firms: N (North) and S (South) [2]. The firms compete with each other on a common market in framework of Cournot duopoly. (Generally, we do not show proofs in following analysis of Cournot equilibrium because they are obvious and standard). There are two different points in time. Initially, one firm in the North and one firm in the South can produce some homogenous good at constant marginal cost, a, and engage in Cournot competition on world market. At the second point the firm N faces an opportunity to devote resources to a deterministic project in order to improve the existing production technology and reduce marginal cost. The firm can achieve a cost reduction of amount $d = (gR)^{1/2}$ by spending R on process innovation, where g is the effectiveness of innovation, and $R \leq a^2/g$. Its post-innovation marginal cost of production will be:

$$C_N = a - d = a - (gR)^{1/2} \tag{1}$$

Three cases are considered here.

The first, the firm N transfers new technology to the firm S. The firm S simulates the new technology. Therefore, post-innovation marginal cost of firm S will also be:

$$C_S = a - d = a - (gR)^{1/2} \tag{2}$$

The second, the new technology is not simulated, i.e. the firm's S cost of production remains:

$$C_S = a \tag{3}$$

The third case takes place when technology has been transferred to firm S is worse than technology the firm N has produced, but it is better than old technology of the firm S. In this case cost of firm S is located between equations (2) and (3).

The first case can occur when: 1) technology is transferred "free of charge" (it is presented or stolen). We traditionally call this case when protection for intellectual property rights is absent as violation for intellectual property rights and denote as V (violated); 2) technology is transferred in exchange for reward (paid out only once or paying systematically). We call this case as license. The second case when technology is not transferred we call as full protection for intellectual property rights and denote as P (protected).

If the case P takes place, the firm N gets the better of the firm S, and either the firm S will be out of market - we can see an unfettered monopoly, or firm N imposes to leave market on firm S and does not allow to enter again. In our analysis we do not distinguish these situations. Note that the firm N in framework of the model defines innovation cost R in order to maximize post-innovation profit but value of the cost determines economical situation that may occur on a market.

Let demand in the integrated market function be linear, and inverse demand function is denoted as $P = b - (q_N + q_S)$, where q_N and q_S are outputs of the firm N and the firm S accordingly, and P is equilibrium price. Let consumer demand on the South be a fraction 1/t of total demand for any prices, i.e. volumes of sale on the South and on the North equal 1/t and (t – 1)/t accordingly. We suppose the consumer surplus has the same distribution. The marginal cost is constant. In other words, we present dynamic game with two steps. During the first step the firm N takes a decision on amount of innovation cost. Then the two firms engage in Cournot competition. According to sub-Nash equilibrium, the firm N should decide on cost R in order to take into account the results that may occur on the second step. Remind that there are possible two cases: intellectual property rights are protected (case P) and intellectual property rights are violated (case V). In all of the cases following situations may occur. In case P, three types of equilibrium may arise: 1) asymmetric duopoly (AD), 2) monopoly of strategic predation (MSP), and 3) unfettered monopoly (UM). Which of them will arise depends upon the size of parameter g describing the effectiveness of innovation in reducing production costs. It is illustrated, if $0 \leq g < g_1$ AD will characterize the competition. If $g_1 \leq g \leq g_2$ MSP will be arose. If $g_2 < g < g_{max}$ UM will correspondent to this market. (In our settings, $g_1 = 1.5$, $g_2 = 2$, $g_{max} = 4$, and value of g_{max} is a result of innovation cost positivity).

In the case V (it is symmetric duopoly), the only regime can arise. It is clear, in this case profit of the firm S is always higher then firm's N profit because the firm N spends money for new knowledge and researches that reduced its profit. In the case P, profit of firm N is always higher than profit of firm S. We compare levels of welfare in each country and for the world as a whole across two regimes P & V. What is better: to keep intellectual property rights up or not? As analysis shows, the share of countries in the international economy, i.e. amount of consumer surplus, becomes to play the principal role. As have been shown the North always benefits in case P; but there are two different situations on the South: for relatively high g and relatively large share of consumers' market, case P is more profitable; for relatively small g, the South benefits in case V. In other worlds, if effectiveness of technological change is high and share of the South on a market is large, the South benefits from providing the protection of intellectual property rights.

Therefore, either the conflict of interest between the North and the South in regard to system of intellectual property rights exists: case P is profitable for the North but the South benefits in case V, or their interest agrees: case P is profitable for both the North and the South.

The conflict of interest clears the way for corruption. In this case, the South benefits from bribery of the North officer for advanced technology. The size of graft depends on gains and waste of each of countries. Then it is possible to calculate the corrupt waste. We define it as the difference between welfare on the North and the South in the cases P and V.

Next consider total welfare. It can be shown that for small g, the case V is more profitable than the case P, and vice versa, for high g, the case P is favorable. In other worlds, the intellectual property rights should be protected when effectiveness of innovation is high and should not be when the effectiveness is low. In terms of corruption we can conclude that protection-rights- oriented corruption is not profitable for society when the effectiveness of innovation is low and is profitable when the effectiveness is high. It means, therefore, that if effectiveness is low, and the North offers bribe to the Southern government in order to protects its intellectual property rights of the North this activity ought to be strongly chased as unprofitable for society. When the effectiveness is high, corrupt activity of the South which aims to bribe the North in order to get the technology is also unprofitable. It is necessary to suppress this corrupt action! In the both cases we can just calculate the corrupt waste to show it.

Look at this situation from opposite point of view. When transferring of technology is profitable for society as a whole (when the effectiveness is low) and is illegal, the violate-rights-oriented corruption promotes cooperation and is profitable for society! When the effectiveness is high the society benefits from the corruption if it is oriented to cancel "beneficent" transferring of technology from advanced country to developing one. Though, it is tempting to suppose that "beneficent" transferring is profitable because total amount of products rises, and prices decrease. The effects showed above are very important because they illustrate that the corruption may either promote or prohibit technological change. However, the consequence of corruption depends on the situation. Similar analysis can be carried out in the case of technology transfer with licensing.

The next notations will be used:

a - marginal cost before innovation has occurred

d - cost reduction

R - innovation cost

g - effectiveness of innovation

C_N - post-innovation marginal cost of production on the North

C_S - post-innovation marginal cost of production on the South

c_N, c_S - marginal cost per unit product of the firm N and the firm S accordingly

Q_N, Q_S - consumer surplus on the North and on the South

W_N, W_S - welfare on the North and on the South

W - total welfare

$z_N = z_N(c_N, c_S)$ and $z_S = z_S(c_N, c_S)$ - profits functions that are profits of the firm N and the firm S in the Cournot duopoly at prices c_N and c_S accordingly

1/t - a fraction of total sale (consumption) on the South

(1 – 1/t) - a fraction of total sale (consumption) on the North

q - total output on the North and on the South

$p = b - q$ - price

B(R) - value of bribe the firm N have got for transfer of technology

L - license payment

l - a share of total profits growth.

In a number of cases, we use these notations with additional indexes P, V and K that correspond to protection of intellectual property rights, violation of intellectual property rights, and corruption.

3. Technological transfer with licensing and corruption

In this section, we present a model of corruption that can arise when agents conclude technological transfer agreement under licensing, i.e. the innovator grants its superior technology to the simulator in exchange for license payment. Thus, intellectual property rights are still protected, but the technology might be transferred. As before, we use the North - South scheme of interaction.

We consider three players: the firm N, the firm S, and official. The official is on the South, i.e. he is on the part that is going to purchase the superior technology. Signing of technological transfer agreement proceeds in two stages:

- 1st stage is legal negotiations;
- 2nd stage is illegal, corrupt agreement.

On the first stage, the firm N and the firm S conclude an agreement about the technology the firm N will produce spent resource R. At that it will reduce its marginal cost and, if transfer of technology occurs, will reduce firm's S marginal cost also. Transfer of technology occurs, as a result of license agreement. The firm N gets license payment L, that is added to its profits and subtracted from profits of the firm S. Amount of license payment, naturally, depends on "quality" of transferred technology and the gain the firm S will get from the transfer. This is a result of legal stage.

Here we do not consider issue of license payment as a special problem. It is well illuminated in literature [2]. Amount of license payment L depends on profits of two firms N and S. We suppose that if the new technology is introduced, and license payment is transferred, the firm S will have no waste for innovation activity (for the firm S, application to production is free of charge). The firms conclude for a share l of total profit growth, which defines amount of license payment L. In its part, having been informed, the firm N chooses optimal level of innovation cost, R, by maximizing its profits equal to sum of two values: the profits it will get from transferring of technology (subject to innovation cost) and license payment.

Notice that, since the firms operate on a common market, then transferring technology the firm N acquires a rival on the South because the firm S has the same marginal cost when technology has been transferred.

The second stage is an agreement between the firm N and the official. The latter presents "interests" of the firm S for quality of the technology that will be transferred. The firm N offers to the official a bribe in order to really transferred technology will be worse then the technology should be transferred according to the agreement signed at the first stage. The official "shuts his eyes" and accepts it instead of the technology for which the simulator has paid to innovator a value L. Thus, the firm N reduces borrowing power of the firm S on the common market, and the officer gains a bribe B in money. Obviously that the bribe is subtracted from total profits of the firm N. However, corrupt action might be revealed with a certain probability. In this case, the two agents will be punished: the firm N will be fined on the license payment has been got; the officer also will be punished by a fine depending on size of the bribe he has got. Each of them maximizes expected value of its profits subject to "penalty" for corrupt behavior. We assume that the officer chooses size of bribe, that he would like to gain, as a part of the firm N real profits plus a certain guaranteed amount "for risk". The firm N defines "quality" or "type" of technology it transfers to the firm S or, rather, value of the firm's S marginal cost reduction after the technology is transferred. We also suppose that the firm N transfers worse technology then it uses by itself, and which is an object of agreement on the first stage. Given this framework, we assume that at first, a formal contract is signed, and, then, a private agreement is concluded.

The corrupt bargain between the firm N and the officer is modeled as a Nash equilibrium.

Note that all our assumptions about demand and cost linearity and all notations from the sections 1 and 2 are correct in this section.

In this section, we analyze the influence of corruption on

1. profits of the firms N and S,
2. welfare of the two firms,
3. total welfare.

For this propose, we choose optimal cost, R, to maximize the firm's N profit when the license agreement is concluded (appropriate equations is given in [2], see also [12]). It is the first stage of signing of license agreement.

The firm N chooses R as a solution of the following problem:

$$\max z_N^L(R) = z_N(c_N, c_N) + L(c_N) \tag{1}$$

where the first item is profits of the firm N on a common market minus innovation cost R. The second item is value of license payment. It is determined as

$$L(c_N) = (z_N(c_N, c_S) - z_S(c_N, c_S)) + l[z_N(c_N, c_N) + z_S(c_N, c_N) - \\ - z_N(c_N, c_S) - z_S(c_N, c_S)], \tag{2}$$

where l is a part of total grow of firm's N profits. It is clear that if

$$\max z_N^L(R) = z_N(c_N, c_S) + l[z_N(c_N, c_N) + z_S(c_N, c_N) - \\ - z_N(c_N, c_S) - z_S(c_N, c_S)], \tag{3}$$

where $c_N = a - (gR)^{1/2}; \quad c_S = a.$

the solution of problem (3) is

$$\overset{*}{R}{}^{L} = \frac{g(2+l)^2(b-a)^2}{(9+(3l-4)g)^2}. \tag{4}$$

Then

$$L = \frac{\left[(2+2l)(b-a)g^{0.5}(R_L)^{0.5} + (3-3l)g \cdot R_L\right]}{9},$$

where $R_L = \overset{*}{R}{}^{L}$.

It can be shown that a license agreement (i.e. $L/R^{*L} > 0$) takes place if, and only if, $g < g^{*} = G(l)$ at $G' > 0$ (g^{*} is a critical value). But if $g < 1.285$, a license agreement will be concluded at any l.

After a license agreement is concluded, profits and consumer surplus of the two firms N and S are

$$z_N^L\left(\overset{*}{R}^{L}\right) = \frac{(b-a)^2}{9(9+(3l-4)g)^2}[81+9g(l^2+10l-4)+ \tag{5}$$

$$g^2(3l^3+17l^2-28l)].$$

$$z_S^L\left(\overset{*}{R}^{L}\right) = z_S(c_N, c_N) - L\left(\overset{*}{R}^{L}\right) = z_S, \tag{6}$$

where

$$z_S = \frac{(b-a)^2\left[81 - 18\,g\cdot l^2 \;\; l \;\; 4 - \left(3l^3 - 15l^2 + 4l - 8\right)g^2\right]}{9\,(9-(4-3l)\,g)^2}$$

$$Q_N^L\left(\overset{*}{R}^{L}\right) = \frac{t-1}{t}\cdot Q^L\left(\overset{*}{R}^{L}\right), \tag{7}$$

$$Q_S^L\left(\overset{*}{R}^{L}\right) = \frac{1}{t}\cdot Q^L\left(\overset{*}{R}^{L}\right), \tag{8}$$

where

$$Q^L\left(\overset{*}{R}^{L}\right) = Q_L := (b-a)^2\,\frac{\left[162 - 72\,g\cdot(2l+1) + 8\,g^2\left(4l^2 - 4l + 1\right)\right]}{9\cdot(9-(4-3l)\,g)^2}$$

Welfare on the North, on the South, and of the system as a whole are given by

$$\overset{*}{W}{}^{L}_{N} = z_N^L\left(\overset{*}{R}^{L}\right) + Q_N^L\left(\overset{*}{R}^{L}\right),$$

$$\overset{*}{W}{}^{L}_{S} = z_S^L\left(\overset{*}{R}^{L}\right) + Q_S^L\left(\overset{*}{R}^{L}\right), \tag{9}$$

$$\overset{*}{W}{}^{L} = \overset{*}{W}{}^{L}_{N} + \overset{*}{W}{}^{L}_{S}.$$

Now we consider the second stage - the corrupt agreement. Remind that on this stage, the firm N chooses the technology it will transfer to the simulator, and the corrupt official defines size of bribe.

We consider utility functions of the two agents, the firm N and the official from the South.

We begin from the official. His utility function equals to utility of income derivable from corrupt behavior minus expected value of penalty. We define the utility function as

$$u_b(B,d) = \sqrt{B} - F_b, \tag{10}$$

where B is a bribe, and F_b is expected value of penalty.
A bribe B can be defined as

$$B = r[(z_N^K - z_N^L) + \omega], \tag{11}$$

where $z_N^K = \left(z_N(c_N, c_N^K) - \overset{*}{R}^L \right) + L\left(\overset{*}{R}^L \right)$, and $z_N(c_N, c_N^K)$ is profits of the firm N on a common market in a Cournot equilibrium with two firms N and S which have marginal cost

$$c_N = a - d_N \text{, or } c_N = a - \left(g \overset{*}{R}^L \right)^{1/2};$$

$$c_S = c_N^K = a - d.$$

Last equation describes the marginal cost of the firm S after the corrupted technology of the firm N has been transferred. The size of bribe Â is defined as a share r of additional profits (growth of profits) the firm N will gain due to transfer of worse technology then stipulated on the first stage, and get additional amount $r \cdot \omega$ for risk. The last one does not depend on market conditions.

Thus,

$$B = r[z(c_N, c_S^K) - z(c_N, c_N) + \omega] \tag{12}$$

or

$$B(d) = \frac{r \cdot \left[2\,(b - a) + 3\,d_N - d \right] \left(d_N - d \right)}{9} + r \cdot \omega\ ,$$

where $z(c_i, c_j)$ is profits without the deduction of cost $\overset{*}{R}^L$ in a Cournot equilibrium with corresponding marginal cost.
The function F_b (expected value of penalty) is

$$F_b = F_b(B,d) = r \cdot q \cdot p_S(D) D_{\max}, \tag{13}$$

where D is "waste" of the firm S. It is given as

$$D = z_S^L - z_S(c_N, c_S^K), \tag{14}$$

$$D_{\max} = z_S(c_N, c_N) - z_S(c_N, c_S), \tag{15}$$

or

$$D_{max} = 4(b - a)\frac{d_N}{9},$$

$p(D)$ is probability of detection the corruption, q is the parameter of risk.

Thus, we assume that the value of penalty is determined by maximum waste that equals to the difference between profits of the firm S in cases when licensed technology is transferred, and its technology remains old. The probability of detection the corruption depends on the waste of the firm S results in corrupt bargain: the larger waste, the more it is evident. But even if the waste is zero, the corruption can be detected. We take it into account by prefacing an additional parameter.

Now we define the firm's N utility function as

$$u_N(r, d) = (z_N^K - B) - F_N, \tag{16}$$

where F_N is expected value of penalty for the corrupt bargain. It is defined as product of probability of corruption detection on the North (the probabilities of detection on the North and on the South as well as amounts of penalty can be disagreed), the risk parameter m, and value of penalty equals to license payment L.

Thus,

$$F_N = m \cdot p_N \cdot L. \tag{17}$$

Assume that the probability of the firm N penalty for corruption depends on how bad the transferred to the firm S technology is, i.e. on the ratio between d_N and d, where $d_N = d_L = (g R^{L})^{1/2}$, and d is value characterizing the degree of marginal cost reduction.

$$c_N = c_L = a - d_L, \quad c_S = a - d.$$

Choose the function $p_N = p_N(c_L, c_S) \equiv p_N(d_L, d) = p_N(d)$ (for short) in order to $p_N'(d) < 0$ and $0 \le p_N(d) \le 1$ at $0 \le d \le d_N$.

It is necessary to pay attention to such important point that the function $u_N(d)+F_N(d)$ is convex of d and so it achieves the maximum on a boundary, either at 0 or at d_N. Therefore, $F_N(d)$ should be convex "enough" in order to the function $u_N(d)=\overline{u}(d)-F_N(d)$ transforms $u_N(d)+F_N(d)$ to a function has maximum within the interval.

This fact is important enough because it illustrates that under corruption, the penalty either prevents or maximizes corruption waste. Just this case, when all or nothing is transferred, is considered in innovation process literature. However, in analyze below, we will present the more realistic situation when transferring technology is better than old one, but worse than license one.

The firm's S profits under a corrupt agreement is given by

$$z_{SK}(d)=\frac{1}{9}\cdot\left(b-a-d_N+2\cdot d\right)^2-L, \tag{18}$$

and total consumer surplus of the North and the South is

$$Q_K(d)=\frac{\left[2(b-a)+d+d_N\right]^2}{18}. \tag{19}$$

We determine equilibrium in two-person game, the official and the firm N, with strategies r and d as a Nash equilibrium, i.e.

$$u_B\left(\overset{*}{r},\overset{*}{d}\right)\geq u_B\left(r,\overset{*}{d}\right)\ \text{if}\ 0\leq r\leq 1, \tag{20}$$

$$u_N\left(\overset{*}{r},\overset{*}{d}\right)\geq u_N\left(\overset{*}{r},d\right)\ \text{if}\ 0\leq d\leq d_N. \tag{21}$$

We call the couple $\left(\overset{*}{r},\overset{*}{d}\right)$ as a corrupt equilibrium.

The official utility function equals to

$$\begin{aligned}u_B(r,d)&=\sqrt{r\cdot(z_N(a-d_N,a-d)-z_N(a-d_N,a-d)+\omega)}-\\&-r\cdot q\cdot p(D(d))\cdot D_{\max},\end{aligned} \tag{22}$$

where $r\cdot\omega$ is payment to the official for his participation in corrupt activity. Now the value of bribe can be defined.

Let

$$\Delta z_N = z_N(a-d_N, a-d) - z_N(a-d_N, a-d_N), \tag{23}$$

$$\Delta z_S = -z_S(a-d_N, a-d) + z_S(a-d_N, a-d_N). \tag{24}$$

Introduce the function of probability of corruption detection on the South as

$$p(\cdot) = \frac{\Delta z_S + \alpha}{1 + \Delta z_S + \alpha} \cdot p \tag{25}$$

At that, the probability of corruption detection is positive even if waste of corruption is absent because of the positive constant α.

The right parts of equations (22) - (25) can be rewritten by the parameters d_N and d:

$$\Delta z_S(d) = 4((b-a)+d)\frac{(d_N - d)}{9} \tag{26}$$

$$\Delta z_N(d) = \left[2(b-a) + 3d_N - d\right]\frac{(d_N - d)}{9} \tag{27}$$

Now the function (22) can be written as

$$u_B(r,d) = \sqrt{r \cdot \left(\frac{1}{9}(2\cdot(b-a) + 3d_N - d)(d_N - d) + \omega\right)} - r \cdot p \cdot q \cdot \frac{\alpha + \frac{4}{9}\cdot((b-a)+d)(d_N - d)}{1 + \alpha + \frac{4}{9}\cdot((b-a)+d)(d_N - d)} \cdot \frac{4}{9}(b-a)d_N \tag{28}$$

The firm's N utility function equals to

$$u_N(r,d) = z_N^K - B = (1-r)\cdot z_N(c_N, c_S^K) + r\cdot(z_N(c_N, c_N) - \omega) - \overset{*}{R}{}^L + L - F_N,$$

or,

$$u_N(r,d) = (1-r)\cdot z_N(a-d_N, a-d) + r\cdot z_N(a-d_N, a-d_N) - \overset{*}{R}{}^L + L - r\cdot\omega - m\cdot p_N(d)\cdot L. \tag{29}$$

We define the probability of detection of corrupt bargain on the North as

$$p_N(d) = p_N\left(\frac{1}{1 - k\dfrac{d}{d_N}}\right) \tag{30}$$

where k is a positive constant, with the help of which we control the probability of detection when the waste is absent.

Hence, the utility function on the North is

$$u_N^K = z_{NK} - \frac{1}{9}\cdot\left[(b - a) + 2d_N - d\right]^2\cdot(1 - r) + \tag{31}$$
$$+\left[\frac{\left[r\cdot\left[(b - a) + d_N\right]^2\right]}{9} - r\cdot\omega - R_L + L\right] - m\cdot L\cdot p_N\cdot\left(\frac{1}{1 + k\cdot\dfrac{d}{d_N}}\right)$$

Now we proceed to search corruption equilibrium as a common solution of the equations (20) and (21).

At first, we consider the problem (20).

It follows from (20), (22), and (28) that either $\overset{*}{r} = 0$, or $\overset{*}{r} = 1$, or according with the first-order condition

$$\frac{\partial}{\partial r}u_B(r, d)\Big|_{r=\overset{*}{r}} = 0\,. \tag{32}$$

Then, at $r(d) > 0$ and $r(d) < 1$, solution of this problem is

$$\overset{*}{r}(d) = \frac{(\Delta z_S(d) + \alpha + 1)^2\cdot(\Delta z_N(d) + \omega)}{(2p\cdot q)^2 D_{\max}^2\cdot(\Delta z_S(d) + \alpha)^2}, \tag{33}$$

or

$$r = \left[4\left((b - a) + d\right)\frac{(d_N - d)}{9} + \alpha + 1\right]^2 \times \tag{34}$$
$$\times\frac{\left[\left[2(b - a) + 3d_N - d\right]\dfrac{(d_N - d)}{9} + \omega\right]}{\left[4\left((b - a) + d\right)\dfrac{(d_N - d)}{9} + \alpha\right]^2\cdot(2p\cdot q)^2\cdot\left[4(b - a)\dfrac{d_N}{9}\right]^2}$$

Look at the equations (21) and (31).

It follows from the first-order condition for this function that

$$0=\frac{-1}{3}\cdot\left(b-a+2\cdot d_N-d\right)\cdot(1-r)-\left(\frac{1}{3}\cdot b-\frac{1}{3}\cdot a-\frac{1}{3}\cdot d\right)\cdot(1-r)+m\cdot\frac{p_N}{\left(1+k\cdot\frac{d}{d_N}\right)^2}\cdot\frac{k}{d_N} \qquad (35)$$

At $0 \le d \le d_N$ and $1 \ge r \ge 0$, the system of equations (34) and (35) defines a Nash equilibrium - corruption equilibrium - in internal points of the intervals. This system of equations may have either no solution, or unique solution or a number of solutions that are maximum of corresponding utility functions. It is internal points that are of special interest of us, since transferring of impaired technology occurs there. In particular, this fact essentially distinguishes the model of this section from the models discussed in the section 2.

Knowing a corruption equilibrium, it is possible to calculate expected profits of the North and the South, consumer surplus, and welfare functions of the North, the South, and the system as a whole at these r and d and compare these values with the values have been got as a result of license agreement on the first stage. By this way, we can estimate the influence of corruption on the change of profits as well as consumer surplus and welfare. The equations need for such calculations is (19), (20), and (31), as well as (5) - (9) as well as

$$\Delta\ W_S(d) := z_{SK}(d) + \frac{1}{t}\cdot Q_K(d) - z_S - \frac{1}{t}\cdot Q_L$$

$$\Delta\ W_N(d) := z_{NK}(d) + \frac{(t-1)}{t}\cdot Q_K(d) - z_N - \frac{(t-1)}{t}\cdot Q_L$$

$$\Delta\ W(d) := z_{NK}(d) + z_{SK}(d) + Q_K(d) - z_N - z_S - Q_L$$

Figures 1 - 8 illustrate the change of expected utility functions of the North, profits of the South, utility of the official, the welfare of the North, the South, and the system as a whole at different values of innovation effectiveness g. The corruption equilibrium is calculated at following values of parameters: *p = 0.1, alfa = 0.01, omega = 0.01, a = 1, b = 2, m = 1, q=250, k = 20, l = 0.5, t = 1.25.*

Table 1 shows examples of a number of such corruption equilibrium calculated at different values of the parameter g. We adduce couple graphs for each equilibrium: Fig. 1 and Fig. 2 are at g = 0.6, Fig. 3 and Fig. 4 are at g = 0.8, Fig. 5 and Fig. 6 are at g = 1, and Fig. 7 and Fig. 8 are at g = 1.2.

Table 1. Equilibrium states for the model of technological transfer with licensing

$g = 0.6$	$g = 0.8$	$g = 1$	$g = 1.2$
$d^* = 0.0605$	$d^* = 0.061$	$d^* = 0.0731$	$d^* = 0.0883$
$r^* = 0.504$	$r^* = 0.183$	$r^* = 0.085$	$r^* = 0.045$
$z_N^K = 0.171$	$z_N^K = 0.225$	$z_N^K = 0.283$	$z_N^K = 0.353$
$u_b = 0.103$	$u_b = 0.073$	$u_b = 0.059$	$u_b = 0.0.51$

I corresponds to change of the North welfare; II is change of the South welfare; III characterizes change of total welfare; A is utility of the North; B is utility of the official; and C is utility of the South.

Fig. 1: Change of the total welfare, the North welfare, and the South welfare at g = 0.6

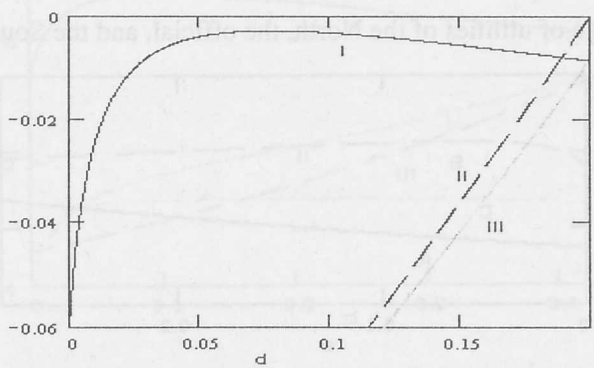


Fig. 2: Change of utilities of the North, the official, and the South at g = 0.6

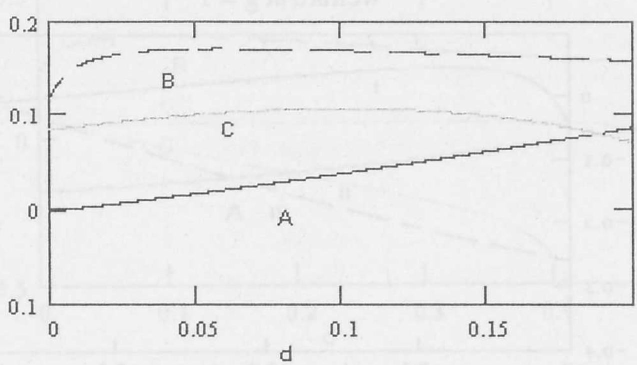


Fig. 3: Change of the total welfare, the North welfare, and the South welfare at g = 0.8

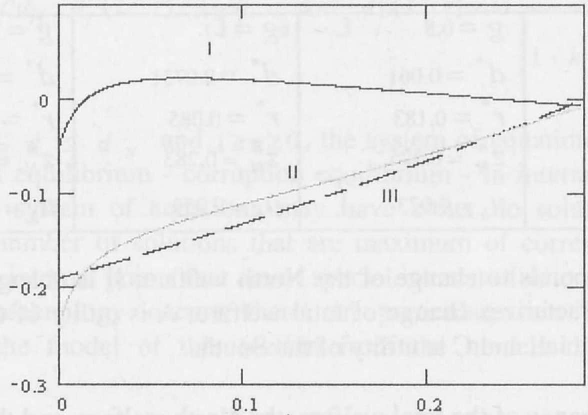


Fig. 4: Change of utilities of the North, the official, and the South at g = 0.8

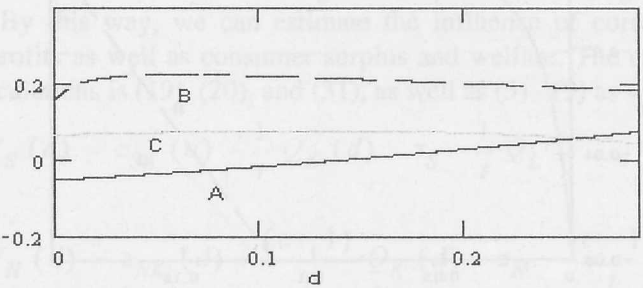


Fig. 5: Change of the total welfare, the North welfare, and the South welfare at g = 1

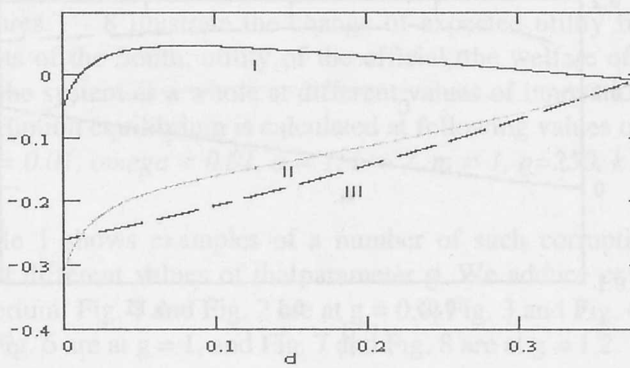


Fig. 6: Change of utilities of the North, the official, and the South at g = 1

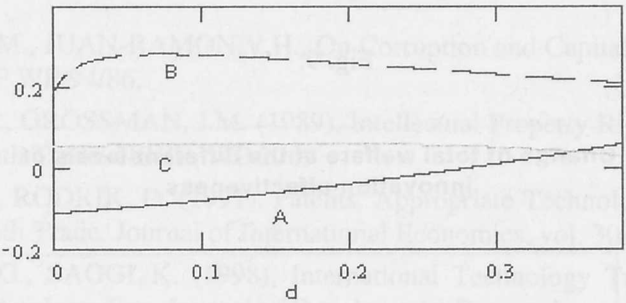


Fig. 7: Change of the total welfare, the North welfare, and the South welfare at g = 1.2

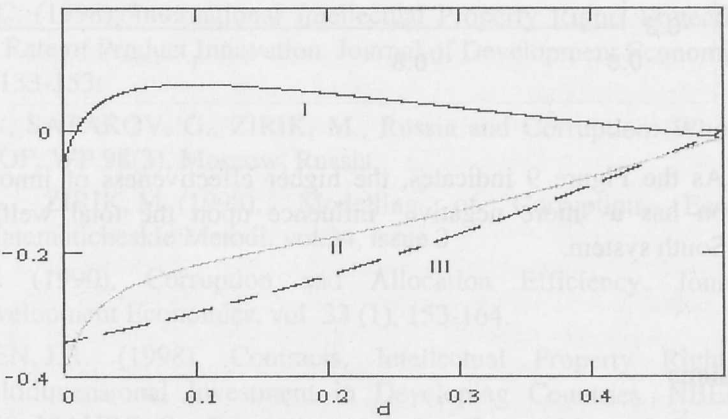


Fig. 8: Change of utilities of the North, the official, and the South at g = 1.2

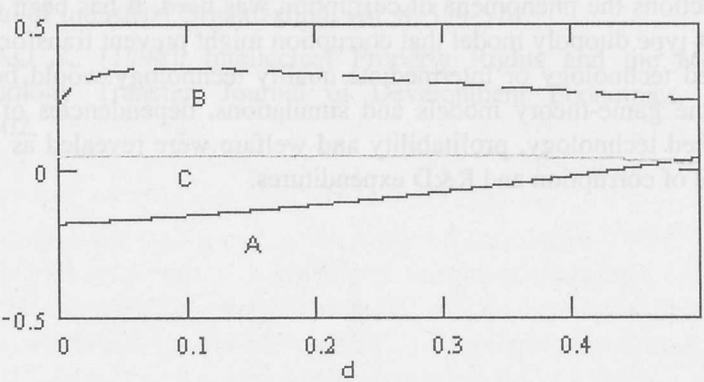
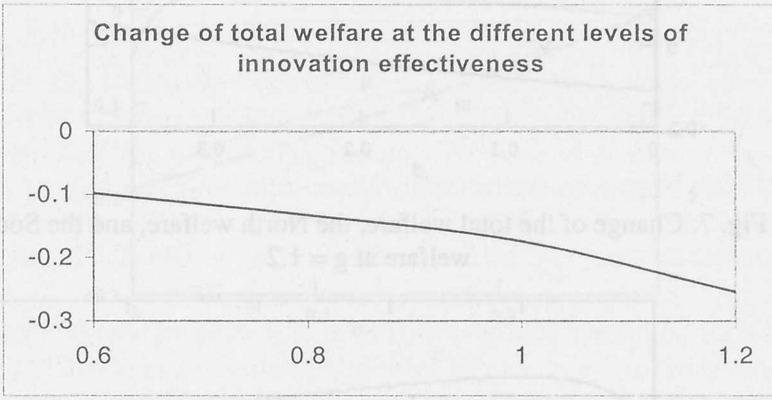


Figure 9 illustrates influence of innovation effectiveness on the change of the total welfare under corruption equilibrium.

Fig. 9:



As the Figure 9 indicates, the higher effectiveness of innovation, the corruption has a "more negative" influence upon the total welfare of the North - South system.

Conclusions

In this paper we have designed the models for analysis the consequences of institutional imperfections on firm level technology diffusion. As institutional imperfections the phenomena of corruption was used. It has been considered in Cournot-type duopoly model that corruption might prevent transformation of the advanced technology or intermediate quality technology would be transferred. Using the game-theory models and simulations, dependencies of the level of transferred technology, profitability and welfare were revealed as a function of the level of corruption and R&D expenditures.

References

ASILIS, C.M., JUAN-RAMON,V.H., On Corruption and Capital Accumulation. IMF WP/94/86.

CHIN, G.C., GROSSMAN, J.M. (1989), Intellectual Property Rights and North-South Trade. NBER, WP 2769

DIWAN, I., RODRIK, D. (1991), Patents, Appropriate Technology, and North-South Trade. Journal of International Economics, vol. 30, 27-47.

GLASS, A.G., SAGGI, K. (1998), International Technology Transfer and the Technology Gap. Journal of Development Economics, vol. 55, 369-398.

HELPMAN, E., (1993), Innovation, Imitation, and Intellectual Property Rights. NBER, WP 4081.

LAI, E.L.-C. (1998), International Intellectual Property Rights Protection and the Rate of Product Innovation. Journal of Development Economics, vol. 55 133-153.

LEVIN, M., SATAROV, G., ZIRIK, M., Russia and Corruption: Who Wins? SVOP, WP 98(3), Moscow, Russia.

LEVIN, M., ZIRIK, M. (1998), Modelling of Corruption. Economica i Matematicheskie Metodi, vol.34, issue 3

LIEN, D.D. (1990), Corruption and Allocation Efficiency. Journal of Development Economics, vol. 33 (1), 153-164.

MARKUSEN, J.R. (1998), Contracts, Intellectual Property Rights, and Multidimensional Investment in Developing Countries. NBER, WP 6448 MAURO, P., Corruption and the Composition of Government Expenditure. Journal of Public Economics, vol. 9 (1998), 263-279.

ROCKETT, K. (1990), The Quality of Licensed Technology. International Journal of Industrial Organization, vol. 8, 559-574.

VISHWASRAO S., (1994), Intellectual Property Rights and the Mode of Technology Transfer. Journal of Development Economics, vol.44, 381-402.