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TAX EVASION AND CORRUPTION IN FISCAL ADMINISTRATION

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В настоящей дипломной работе изучается задача оптимальной организации работы налоговой инспекции в том случае, когда инспекторы, осуществляющие налоговые проверки, коррумпированы. Для того чтобы предотвратить уклонение от налогов налоговая инспекция должна осуществлять случайные проверки деклараций дохода. Издержки на эти проверки могут являться существенной статьей расходов. Проверки осуществляются налоговыми инспекторами, которых можно подкупить. Поэтому, налоговая инспекция иногда перепроверяет тех инспекторов, которые подтверждают сообщения о низком доходе. Наказанием для инспектора является его увольнение.

Данная работа описывает поведение налогоплательщиков и инспекторов в модели с двумя уровнями дохода. Основной результат заключается в том, что оптимальной стратегией налоговой инспекции является предоставление инспекторам возможности забирать весь штраф, который накладывается на нечестных налогоплательщиков. Такая система позволяет избавиться от коррупции и устраняет необходимость перепроверок. Также, при некоторых предположениях, этот результат удается обобщить на случай непрерывного распределения доходов.

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The present master thesis studies the problem of efficient organization of tax inspection in presence of corruption. In order to prevent tax evasion the tax authority need to conduct random audits of taxpayers' income reports, which are costly. These audits are conducted by inspectors who can be bribed. For this reason the tax authority may review inspectors who confirm low income. The penalty for dishonest inspector is his firing.

The paper describes the equilibrium behavior of taxpayers and inspectors in the model with two levels of income. The main result of this work is that it is optimal to give an inspector the full incentives by letting them to take the whole fines imposed on dishonest taxpayers. In this case there is no corruption and reviewing becomes unnecessary. Moreover, this result is generalized for the case of continuous distribution of income and linear tax schedule.

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CONTENTS

1. INTRODUCTION.

Tax evasion is a serious problem not only in transition economies but also in countries with developed tax system. Even in the United States the rate of the tax evasion is estimated at about 30%. An important aspect of the work of the tax authority is the possibility of corruption. Dishonest taxpayers who underreport their income may bribe inspectors. The presence of this phenomenon may significantly reduce the tax revenue. Therefore, in determining its auditing strategy, the tax authority should take into account the possibility of corruptness of its inspectors. The present thesis provides a theoretical study of the problem of the optimal organization of tax inspection in presence of corruption. First, using a game-theoretic approach, in the model with two levels of income the behavior of taxpayers and inspectors under different auditing strategies is described. Second, the result about optimal auditing strategy and the system of payment to inspectors is established.

Corruption in fiscal bodies is a recognized fact. In such countries as India or Taiwan surveys show that more than half of interviewees usually pay bribes to tax officials (Keen, Hindriks, Muthoo (1998), Mookherjee, Png (1995))[1]. There exists a widespread opinion that the level of corruption within fiscal bodies in Russia is relatively substantial. The most important reason for that seems to be a very low salary of tax inspectors. For instance, in Russia the salary of a tax inspector was about \$150-\$200 in 1996. This leaves strong incentives for accepting bribes from firms (or individuals) evading much greater amount of the tax liabilities. Tax

[1] Keen, Hindriks, Muthoo (1998) citing Chu(1990) write that surveys in Taiwan report 94 per cent of interviewees as having been led to bribe corrupt tax administrators and 80 per cent of certified public accountants as admitting to bribing officials .

authority may significantly improve situation by giving inspectors more incentives to behave honestly. This may be fulfilled by giving an inspector the possibility of receiving some share of fines they collect from dishonest taxpayers. It is important to note that such system, if designed appropriately, will not significantly reduce the revenue of the tax authority which maximization is usually its final goal. By reducing agents' incentives to become corrupt this scheme reduces taxpayers' incentives to evade. Less evasion implies that less fines are actually imposed and therefore less premiums are paid.

The work of the tax inspection with corruptible inspectors may be briefly described as follows. Taxpayers declare their income either truthfully or not. Tax authority hires inspectors in order to conduct random audits of taxpayers with some probability. Those taxpayers who are determined being evaders must pay the fine. The possibility that inspectors can be bribed induces the tax authority to conduct additional random audits of tax inspectors which are costly. In the work by Vasin, Panova (1998) the model with two levels of income was developed. The solution to the problem of the net revenue maximization with respect to probabilities of auditing, reviewing and inspector's salary was found. The paper by Vasin and Panova assumed that the penalty for corruptible tax inspector has some fixed monetary value. In contrast, the present work shows that if the penalty for dishonest inspector is his firing the behavior of agents becomes more complicated. Under this assumption the minimal value of bribe acceptable for tax inspector depends on the proportion of evaders among taxpayers with high income. The higher is this share, the greater is the minimal bribe.

The introduction of premiums in this setting gives the tax authority the opportunity to eradicate corruption at a low cost. It is sufficient to let inspectors to take the whole fine for evasion. Then the optimal auditing strategy of the tax authority is to set the probability of auditing at the minimum necessary to deter taxpayers from evasion and to set the salary at the minimum level necessary to hire enough inspectors to accomplish the work. This result is also extended to the case with continuous distribution of income. It is shown that the similar result holds for the case with proportional taxation and linear fines.

In the literature on tax evasion there are two different approaches to modeling tax evasion. The first approach assumes, in the usual principal agent tradition, that the tax authority is a Stackelberg leader in its choice of tax-audit schemes, which taxpayers subsequently take as given in deciding what income level to report (see e.g. Reinganum, Wilde (1985), Border, Sobel (1987), Mookherjee, Png (1989), Chander, Wilde (1998), Vasin, Panova (1998)). The alternative approach assumes that the revenue authority cannot credibly commit to an announced audit strategy, rather it chooses myopically its optimal responses to reporting strategies of taxpayers (see e.g. Melumad, Mookherjee (1989), Chander, Wilde (1992)). The first approach which is used in the most part of the literature is followed in the present work.

2. A SURVEY OF LITERATURE

Tax evasion was extensively studied within the economic literature. The presence of this phenomenon can be explained theoretically by the two main reasons : by properties of the tax schedules such as an excessive progressivity of taxes and by the impunity of evasion, in particular, because of the inability of the tax authority to organize its work in such a way so as to induce taxpayers to pay taxes correctly, by optimally choosing its auditing strategies (and schemes of payment to inspectors).

The two different problems are, first, the problem of the tax authority of the net revenue maximization under fixed tax schedules and, possibly, fixed penalties for evasion. The more general problem is the problem of introducing the scheme of tax schedules and auditing probabilities that would enforce honest behavior of the taxpayers. The reason for studying the problem of tax evasion under fixed tax schedule is that the choice of tax schemes is not in the competence of the tax authority but rather of another institutions such as Parliament and is the matter of general consent in the society. In choosing tax rates the main concern is usually equity which explains the resulting progressivity of taxes observed in most countries. However, increasing tax rates raise incentives for taxpayers to underreport their incomes in order to evade paying high taxes which in turn requires higher expenditures for auditing. This is a well known equity-compliance or equity-efficiency trade-off (see e.g. Chander, Wilde (1998), Hindriks, Keen, Muthoo (1998)). The Russian tax authority, the ministry for taxes and duties, recognizes this particular problem. An attempt of introducing a “more regressive” tax schedule was recently made, but this, probably, seems a too radical solution for legislators who are concerned more with equity rather than efficiency.

The penalties for misreporting are also usually not a choice variable for the tax authority. Although it would be very easy to overcome evasion by increasing penalties unboundedly, this does not seem to be an appropriate solution in reality. Tax authority should always weigh the punishment against the crime. False reporting of income may always become a matter of mistake rather than malicious intent on the part of the taxpayer. Therefore penalties are constrained by social norms and legislation.

These considerations explain why it is natural to study the problem of tax authority facing fixed taxes and fines. This problem is addressed in the papers by Reinganum and Wilde (1985), Border and Sobel (1987), Sanches and Sobel (1993), Chander and Wilde (1992), Vasin and Panova (1998). The first two papers tried to characterize the properties of the optimal audit strategy depending on the properties of the tax schedules. A basic result on optimal auditing of direct taxes appears in Sanches and Sobel (1993). This paper shows that for a linear tax schedule the optimal auditing strategy belongs to the class of the cut-off rule. Under this rule only incomes reported below some threshold level should be audited with some positive probability less than one[2]. This seems to be an important practical result.

Chander and Wilde (1998) consider a more general problem of income tax enforcement. They introduce the notion of an efficient scheme including tax, penalty and auditing probability functions (t, f, p), which are such schemes that does not allow to increase the expected payment of any taxpayer without increasing probabilities of auditing for some reported income. For different objectives of the tax authority the optimal scheme must be efficient. The problem of the tax authority is the problem of optimal mechanism design where a mechanism is a scheme (t, f, p). To each mechanism corresponds an optimal message function of reported income by the taxpayer. The revelation principle holds so that it is possible to restrict attention to incentive compatible direct revelation schemes. Chander and Wilde find that in an efficient scheme the

[2] This result was generalized in the work by Vasin, Panova(98) for unbounded income distribution.

payment function must be nondecreasing and concave, the tax function is nondecreasing with non increasing average tax rate, which implies that there is no redistribution among the taxpayers. The audit probabilities are determined wholly by the marginal payment rates and are nonincreasing. Regressivity implies that the inability of the government to costlessly observe true incomes severely restricts its ability to redistribute through direct taxation. The regressivity result is known from another considerations which take into account the supply side effect (Mirrlees (1971) and others). Although the paper by Chander and Wilde (1998) gives an important insight in the nature of interplay between tax rates, audit probabilities and penalties for misreporting, their results for the reasons presented above are of limited practical importance.

Mookherjee and Png (1989) study the problem of optimal auditing and taxation when agents are taking unobservable actions which affect their income distributions. An important assumption in this paper is risk aversion of the taxpayers. In this setting they also obtain the result that audits should be random, auditing probability is a decreasing function of the tax schedule. Their model also applies to the problem of optimal debt financing.

However, these studies do not take into account an important aspect of the work of any tax inspection, which is the possibility of corruption. Inspectors conducting random audits may collude with evaders by accepting bribes and conceal the results of their audit.

In fighting this phenomenon tax authority may improve situation by increasing the inspectors' salaries and thereby increase an opportunity cost of an inspector for being fired if detected in poor work[3]. This idea was introduced in the work by Vasin and Panova (1998).

In their model taxpayers can earn either high or low income with some positive probability. Taxpayers with high income must pay the tax T. If they decide to evade and then become exposed in evasion they must instead pay the fine F greater than the tax T. Tax authority hires inspectors to conduct random audits. It also reviews those inspectors who confirm low incomes, for the reason that taxpayer and inspector can collude, whereby inspector shields evasion receiving a bribe. Dishonest inspector must pay the fine $\tilde{F}$ Both audits and reviewings impose some fixed costs on the tax authority. First, they study the equilibrium behavior of agents under various probabilities of auditing and reviewing p and p_c

Authors find that there may arise three types of behavior of the taxpayers and inspectors : honest behavior with no evasion, evasion and bribery and evasion without bribery. The plane (p, p_c) separates in three regions which meet at the point $p=T/F$, $p_c = F/(F+\tilde{F})$. Depending on the parameters of the model it is optimal either to set $p=T/F$ and review inspectors with some positive probability or to set the probability of auditing high enough so that evasion becomes unprofitable even if it is possible to bribe an inspector. An important concusion is that the small increase in the tax rate or decrease in fines, if it is not acompanied with adjustment of the optimal policy, may significantly reduce the net revenue from taxes and fines.

Further, inspector's salary as the parameter of optimization is introduced. The optimal solution now essentially depends on the parameters of the model. Sometimes it is optimal to pay an inspector more than his reservation salary. This

[3] It may be rather difficult for the tax authority to reveal the fact of bribing. However if inspector is regularly detected in confirming low income this may point at his corruptness

enables the tax authority to conduct less reviewings. However, an exhaustive consideration of the possibility of firing an inspector as a punishment as well as investigation of the possibility of introduction of premiums as the way to increase the net revenue was left unaccomplished.

The role of giving incentives to the state officials in fighting corruption was recognized within the economic literature (see e.g. Bardhan (1997)). Some countries have accepted systems of tax enforcement which include a bonus to the tax officer based on the amount of taxes he or she collects, which significantly improved tax compliance (see e.g. Bardhan (1997) , Dilip Mookherjee(1995)). A theoretical base for that was recently given in Hindriks, Keen, Muthoo (1998). They show that the honest implementation of progressive tax schedule may require paying commission on high income reports. This paper focuses on the interaction between taxpayers and inspectors when each taxpayer is audited. Inspector may be either bribed or extort higher tax payment from which he gets some commission.

Situation when each taxpayer is audited and an inspector gets commission based on the tax revenue he provides for the tax authority considered in this paper may apply to big enterprises. Their tax payments constitute a significant share of tax proceeds and therefore they are typically on permanent supervision of the tax bodies. Smaller firms or households constitute another group which is much broader and therefore each taxpayer in this group rather pays taxes from the amount of income he estimates himself and then can be randomly audited. In this case the role of inspector is to impose fines on which amount his remuneration can be based. This case is studied in the most of the literature on tax enforcement.

It is rather clear that giving more incentives to state officials may reduce corruption. However, as Bardhan notes in his review on corruption, the objective is not merely to reduce corruption in an official agency but, at the same time, 'not to harm the objective for which the agency was deployed in the first place'. In the context of tax administration the problem is that it is not a priory clear what is the impact on the net revenue which maximization is actually the final objective of the tax authority. Fighting corruption may require excessive resources. But, it may be argued, that in the case of tax collection fighting corruption is in line with the final objective of revenue maximization.

The rest of the paper is organized as follows. Section 3 studies the model with two levels of income under the assumption that the penalty for an inspector is his firing. The equilibrium behavior of agents and the optimal auditing strategy are found. Section 4 studies the situation with continuous income distribution. The optimal strategy is found under linearity assumption. Section 5 concludes.

3. THE MODEL OF CORRUPTION IN TAX INSPECTION WITH TWO LEVELS OF INCOME.

3.1 The Model of tax inspection.

The basic structure of the model is the following. There are only two levels of income $I_L<I_H$, obtained with probabilities $1-q$ and q respectively. The low income level is free of tax and the tax for high income is T. The taxpayers with true high income I_H have an incentive to report I_L. The tax agency conducts random audits

with the probability p of those who declare I_L. The cost of audit c consists of inspector's salary s and some fixed cost $\underline{c}$. Audit always reveals the true income. The fine for underreporting is equal to F and includes the original tax liability. However, an auditor may be bribed, inducing him to suppress the result of the audit, thus shielding a taxpayer who reports I_L instead of I_H from the fine for underreporting. For this reason the central authority randomly checks auditors who confirm low incomes and penalizes them if the review reveals that the inspector has concealed tax evasion. The probability of reviewing is p_c. The cost of reviewing is exogenous and equals $\tilde{c}$[4]. The central authority aims at maximizing the expected net tax revenue including collected taxes and its share of fines less costs of auditing and reviewing. All agents are risk neutral.

The following system of payment to an inspector (of the low level) is supposed. Each inspector receives a fixed salary s. An inspector who exposed the fact of tax evasion receives a premium P_r. If inspector's poor work is revealed he is fired and looses his salary for the current period[5]. At an alternative occupation inspector receives a reservation wage s_{min}. The tax authority should provide inspector with expected revenue of at least s_{min}. The choice variables of the tax authority or its strategy are the four parameters (p, p_c, s, P_r) : the probabilities of auditing and reviewing, the inspectors' salary and premiums. Premiums should not exceed fines for evasion since otherwise inspector and taxpayer will always come to a mutually beneficial collusion : inspector exposes a fictitious evasion and covers the fine which a taxpayer has to pay.

The sequence of events is the following. At the first stage the tax authority sets p, p_c, s, and P_r. Observing these parameters taxpayer with high income chooses

[4] It is supposed that these reviewing is conducted by inspectors of the high level who are known to be honest.

[5] The final result does not change if when fired inspector is left with his last salary.

to declare either I_L or I_H. Then, random audit occurs. If evader meets inspector they either collude, whereby inspector receives bribe and confirms low income, or officially expose evasion whereby taxpayer pays F and inspector gets P_r. Finally, if there was collusion, inspector is reviewed with probability p_c and if his false confirmation the low income is exposed he is fired and taxpayer pays the fine (the bribe is left by the inspector).

First, analyze the conditions under which bribing is possible. An evader will be ready to give an amount of bribe b to an inspector such that $b + p_c F < F$ or

$$b \leq b_{max}(p_c) = F(1-p_c). \qquad (1)$$

The behavior of the inspectors is strategic. In deciding whether to accept bribes or not they compare not only the present benefit of accepting bribe but also future earnings, taking into account the possibility of being fired and loosing the future rents. In order to compare the two alternatives one should introduce the present discounted values of expected earnings of an inspector if he behaves honestly (V_h) and if he accepts bribes (V_b).

Let $\tilde{\mu}$ denote an equilibrium share of evaders among taxpayers with I_H, $\tilde{\mu} \subset [0,1]$. For a given share of evaders $\tilde{\mu}$ the share of agents who declare low income equals $1-q + \tilde{\mu} q$. Therefore, the share of those who evade (have true income I_H) among agents who declare I_L is $\frac{\tilde{\mu} q}{(1-q)+\tilde{\mu} q}$. Let $\mu = \mu(\tilde{\mu}) = \frac{\tilde{\mu}}{(1-q)+\tilde{\mu} q}$. Then, this share becomes μq which is at the same time the inspector's probability of meeting an evader. Notice, that $\mu(\tilde{\mu})$ is just a monotonic transformation of the "true" share of evaders $\tilde{\mu}$ among agents with high income. Also, the function $\mu(\tilde{\mu})$ coincides with its argument at the ends of the interval of its definition [0,1] : as all agents evade both $\tilde{\mu}$ and μ equal 1 and when nobody evades both of them equal zero. Thus, the parameters $\tilde{\mu}$ and μ can be used interchangebly. While the first of them is the equilibrium share of those who evade among those who are potential evaders (that is among all agents with high income), the second serves as an indicator of the equilibrium share of evaders (agents with true high income) among those who declare low income (the exact share is μq). It is natural to call μ the "adjusted" share of evaders. In our further calculations $\tilde{\mu}$ always arises in the form of $\mu(\tilde{\mu})$. Therefore, in what follows, the argument $\tilde{\mu}$ will be suppressed and μ will be referred to simply as the share of evaders.

Now, we turn to the determination of V_b, the present discounted value of expected earnings of an inspector if he accepts bribes. In the current period inspector receives the salary s if he is not fired subsequently (the corresponding probability is $1-(\mu q)p_c$) and the bribe b if he encounters an evader (the probability is μq). The future, which is discounted with factor δ, gives an inspector the same value of expected earnings V_b if he is not fired (the probability is $1-(\mu q)p_c$). If inspector is fired he receives his reservation salary forever, which gives him expected earnings of s_{min}/δ (the probability is $(\mu q)p_c$). Thus, V_b meets the following recursive equation :

$$V_b=[(1-(\mu q)p_c)s+(\mu q)b]+(1-\delta)[(1-(\mu q)p_c)V_b+(\mu q)p_c s_{min}/\delta)] \qquad (2)$$

Solving for V_b one gets :

$$V_b = V_b\,(\mu, b)= \frac{(1-(\mu q)p_c)s+\mu q b+(1-\delta)(\mu q)p_c\dfrac{s_{\min}}{\delta}}{\delta+(1-\delta)(\mu q)p_c}$$

Honest behavior gives an inspector $V_h(\mu) = \dfrac{(\mu q)P_r+s}{\delta}$.

Bribing is profitable if $V_b \geq V_h$. The minimal value of bribe b_{min} acceptable for an inspector is then determined from the condition : $V_b\ (\mu, b_{min}) = V_h\ (\mu)$,

Wherefrom one gets $b_{min} = b_{min}\ (\mu, p_c\ ) = P_r + \frac{p_c}{\delta}[(1-\delta)(\mu q\ P_r - s_{min}) + s]$ (3)

Thus, bribing occurs as long as $b_{min}\ (\mu\ , p_c\ ) \ \leq\ b_{max}(\ p_c\ )$. (4)

For a given equilibrium share of evaders μ this condition is equivalent to

$$p_c \leq p_c\ (\mu) := \frac{F - P_r}{F + \frac{s + (1-\delta)((\mu q)P_r - s_{\min})}{\delta}} \qquad (5)$$

which tells that if p_c is small enough (smaller than $p_c(\mu)$) then bribing is profitable. Note, that if $P_r = F$, $p_c\ (\mu) = 0$, that is if premiums equal fines imposed on dishonest taxpayers any positive probability of reviewing makes bribing unprofitable. For now it is assumed that $P_r < F$. It is supposed that the surplus is divided in the proportion γ, $(0 < \gamma < 1)$ and the resulting bribe is

$$b = \gamma\, b_{max}\ (\ p_c\ ) + (1-\gamma)\ b_{min}\ (\mu, p_c\ ) = b(\mu, p_c\ ). \qquad (6)$$

Note, that since b_{min} increases with μ, b also increases with μ, that is the more taxpayers evade the more is the bribe.

3.2. The equilibrium behavior of agents under various probabilities of auditing and reviewing.

To understand the behavior of the taxpayers first note that if $pF < T$ taxpayers will always evade, because even if p_c is high enough so, that bribing becomes unprofitable, their expected fine payment is smaller than the tax liability. Then we can conclude that if $p < T/F$, $\mu = 1$. In this case bribing occurs if and only if $p_c < p_c(1)$.

Now suppose that $p>T/F$. In this case taxpayers will strictly prefer to evade if $p_c \le p_c(1)$ and $p(b+p_cF) < T$, that is if they know that they will be able to bribe an inspector and the resulting value of bribe is such that their expected payment of bribes and fines is smaller than their tax liability.

Denote $$p(p_c,\mu)=\frac{T}{b(\mu,p_c)+p_cF} \qquad (7)$$

where $b(\mu, p_c)$ is a linear function determined by *(1),(3),(6)*.

The whole region where evasion and bribing occurs is characterized by the conditions :

$0 \le p_c \le p_c(1)$ and $0 \le p \le p(p_c, 1)$, (Region A on fig.1, see Appendix)

For $p>T/F$ evasion is strictly unprofitable when $p(b(\mu, p_c) + p_cF) > T$, that is if the expected payment of bribes and fines exceeds the tax liability. This means that $\mu = 0$ and one should substitute this value in the condition : $p(b(0, p_c) + p_cF) > T$ or $p > p(p_c, 0)$.

It should be noted that, under the last condition, if $p_c \le p_c(0)$, bribing would be profitable if evasion would occur for some reason (e.g. because of a casual mistake of taxpayer in estimating his income), but evasion is unprofitable *per se*. Therefore all agents behave honestly if either $p>T/F$ and $p_c > p_c(0)$ (Region C1 on fig.1) or $p_c \le p_c(0)$ and $p > p(p_c, 0)$ (Region C2).

Suppose now, that taxpayers are indifferent to evading. This occurs under the conditions $p(b(\mu, p_c) + p_c F) = T$ (or $p = p(p_c, \mu)$) and $p_c \le p_c(\mu)$ by some equilibrium share of evaders μ. The region of mixed equilibria (Region D) is characterized by the conditions:

$p \ge T/F$ and $p(p_c, 0) \le p \le p(p_c, 1)$.

For each point (p_c, p) satisfying these conditions there exists a unique equilibrium share of evaders $\mu \subset [0,1]$. This share is determined from the condition

$p = p(p_c, \mu)$ (see (7)).

This region consists of the family of graphs of the functions $p = p(p_c, \mu)$ for $p \geq T/F$ where $0 \leq \mu \leq 1$ (on the fig.1 the dotted curve shows such graph for some share $0 < \mu < 1$). The left and the right boundaries of the region are the graphs of the functions $p(p_c, 0)$ and $p(p_c, 1)$ respectively. For any given value of p above T/F and below $K = p(0, \mu)$[6] the share of evaders decreases with p_c.

The low boundary of the Region D is the segment $[p_c(1), p_c(0)]$, $p=T/F$ (Region E). Since μ here is such that $p_c = p_c(\mu)$, one gets $b = b_{min} = b_{max}$, which implies that all agents become indifferent between colluding or paying the fine to the treasury. Therefore some inspectors may accept bribes while others behave honestly, whereby the share of honest inspectors λ is arbitrary.

These results are summarized in the following proposition :

Proposition 1. *For any fixed values of s and P_r ($P_r < F$), such that inspector's participation constraint is satisfied, the behavior of taxpayers (with high income) and inspectors depends on auditing probability p, and the probability of reviewing p_c as follows :*

A. All taxpayers evade and bribe if : $p_c \leq p_c(1)$.

$$p \leq p(p_c, 1),$$

where $p(p_c, \mu)$ is determined in (7),(1),(3),(6).

B. Taxpayers evade but do not bribe if : $p_c \geq p_c(1)$.

$$p < T/F.$$

[6] Note that $p(0, \mu)$ does not depend on μ, since if there is no reviewing ($pc=0$) the value of minimal bribe is wholly determined by premiums.

C. All agents are honest (no evasion and bribing) if :

$p_c > p_c(0)$ *(no potential bribing)* or $p_c < p_c(0)$ *(potential bribing)*

$p > T/F$ $p > p(p_c, 0)$

D. Some share of taxpayers evade and bribe inspectors if : $p > T/F$

(mixed equilibria) $p(p_c, 0) \leq p \leq p(p_c, 1)$.

The (adjusted) share of evaders is determined from the condition $p = p(p_c, \mu)$.

E. Some share evades, but agents are indifferent to bribing if : $p = T/F$

(mixed equilibria) $p_c(1) \leq p_c \leq p_c(0)$

The (adjusted) share of evaders is determined from the condition $p_c = p_c(\mu)$, *where* $p_c(\mu)$ *is determined in (5).*

Note: at the point *(0,K)* the share of evaders is undetermined. Depending on μ one should assign this point to region A, D or C.

3.3. The Net Revenue of the tax authority.

Suppose that the tax authority aims at maximizing its net revenue which is its expected revenue from taxes and fines minus costs of auditing and reviewing. An alternative situation is when the tax authority maximizes the revenue from taxes and fines facing a restriction of some fixed budget for its auditing expenditures. The reason for that is that sometimes the tax authority do not have a discretion over using resources it collects. However, the whole government, of course, do have such discretion and therefore it seems reasonable to look at the problem of the maximization of the budget revenue of the whole government.

The net revenue of the tax authority in region A is :

$$R_a(p, p_c) = p(p_c(q(F+s) - \tilde{c}) - \underline{c} - s).$$

It increases with p if $p_c(q(F+s) - \tilde{c}) - \underline{c} - s > 0$ and increases in p_c if $q(F+s) - \tilde{c} > 0$. (If these conditions are never satisfied the net revenue is always negative in A). Therefore, if ever positive R_a is maximized somewhere along the curve $p = p(p_c, 1)$ where it is impossible to increase one probability without decreasing the other. Substituting $p = p(p_c, 1)$ in the above expression for R_a one gets the function :

$$R_a(p_c) = R_a(p(p_c, 1), p_c),$$

which is maximized either at point $(p_c(1), T/F)$ or $(0, K)$.

$$(K = p_c(0, m) = T/((1-\gamma)P_r + \gamma F))^7.$$

In the region B the net revenue of the tax authority is given by the expression $R_b(p, p_c) = p(q(F - P_r) - c - (1-q) p_c \tilde{c})$. The revenue falls with p_c and increases with p where it is positive. Therefore it is maximized at the point $(p_c(1), T/F)$

$$(\text{ if } q(F - P_r) - c - (1-q) p_c(1)\tilde{c} > 0).$$

In the region C $R_c(p, p_c) = qT - (1-q)p(s + \bar{c} + p_c \tilde{c})$. It decreases with both p and p_c. It is maximized somewhere along the curve $p = p(p_c, 0)$ where it is impossible to decrease one probability without increasing the other. Substituting $p = p(p_c, 0)$ in the expression for R_c one gets the function $R_c(p_c) = R_c(p(p_c, 1), p_c)$, which is maximized either at the point $(p_c(0), T/F)$ or $(0, K)$.

In the region D the net revenue of the tax authority is given by the linear combination of the expressions R_a and R_c for its revenues in A and C respectively:

$$R_d(p_c\ \mu) := R_d(p(p_c, \mu), p_c) := \mu R_a(p(p_c, \mu), p_c) + (1-\mu) R_c(p(p_c, \mu), p_c)^8.$$

For any given μ $R_d(p_c\ \mu)$ is maximized either at point $(p_c(\mu), T/F)$ or $(0, K)$. Let $R_d(\mu)$ denote the maximum of R_d with respect to p_c, for a fixed value of μ.

[7] This and the similar results for another regions (see below) obtains from the straightforward calculations. They are available upon request.

[8] Points in the region D can parameterized by any two of three parameters p, p_c or μ., since they are connected by the relationship (5)

Then $R_d(\mu)$ decreases with μ and therefore maximum of the net revenue in the region D is achieved, as in the region C, either at the point $(p_c(0), T/F)$ or $(0, K)$.

Finally, in the region E $R_e(T/F, p_c\ \mu,\lambda) := R_e(p_c(\mu),\mu, \lambda) :=$

$$= \mu[\lambda R_a(T/F, p_c(\mu)) + (1-\lambda) R_a(T/F, p_c(\mu))] + (1-\mu) R_c(T/F, p_c(\mu)),$$

where λ is the share of honest inspectors. The net revenue decreases with μ and increases with λ. Note, that if $\lambda=0$, one gets the same expression as for R_d.

On the whole, with respect to p and p_c the net revenue is maximized at the point $(p_c(0), T/F)$ or $(0, K)$.

This situation corresponds to the case $P_r < F$. As can be seen from the expression (5), if the difference $F - P_r$ tends to zero, the minimal probability of reviewing $p_c(\mu)$ necessary to deter agents from bribing tends to zero for any given share of evaders. So, as P_r approaches to F the picture degenerates. If $P_r = F$ then for any positive probability of reviewing bribing is unprofitable and therefore only regions B and C remain (below and above the line $p=T/F$ correspondingly) .

<u>Proposition 2</u>. *In the situation described above the optimal strategy for the tax authority is to set* $P_r = F$, $s = s_{min}$, $p_c = 0$, $p=T/F$.

That is tax authority should let inspectors to take the whole fine for evasion, set the auditing probability p equal the minimum necessary to deter agents from evasion under the case with intrinsically honest inspectors, set the salary at the minimum necessary to hire an inspector (that is satisfy his participation constraint). No reviewing is necessary.

<u>Note.</u> This result may be proved formally by comparing the values of R_c at the optimal point under different values of s and P_r . However, the proof presented below may help better to understand the underlying argument and will be useful

for the cases with risk-averse inspectors and with continuous distribution of income studied below.

Proof. First note that if inspectors are permitted to take the whole fine bribing becomes unprofitable. If premium equals fine inspector will not accept any bribe less than *F*, with which he is guaranteed (this can be seen formally from (*3*)). On the other hand, taxpayer will not pay any bribe greater than *F*, because he can always pay the official fine. (If $p_c = 0$ they are indifferent, whether to name *F* the fine or the bribe because the result is a transfer of *F* from taxpayer to inspector in either case).

Consider now some probability of auditing p and the two situations. First, when inspectors are honest, that is do not accept bribes as a principle, and second when they are venal. In each case they receive some fixed salaries and premiums for exposure. Then, the gross revenue of the tax authority (the revenue from taxes and fines) with honest inspectors is not less than with corrupt ones under any probability of reviewing p_c. To see this note that since all agents are risk neutral this game may be considered as a zero sum game (or a game with transferable utilities). The tax authority makes the first step by declaring its strategy and *only after that* taxpayers and inspectors choose their strategies. Therefore, giving them additional opportunities cannot decrease their joint revenue, because by the process of renegotiations they always come to the optimal agreement when their joint revenue is maximized. But this means that giving them additional possibilities cannot increase the gross revenue of the tax authority.

Second, note that the number of evaders cannot decrease. If a taxpayer evaded in the case with honest inspectors, which is true if $p<T/F$, then he will still evade

if inspectors become corrupt. Therefore auditing costs cannot decrease, not to mention the cost of reviewing which can also arise.

This means that under any strategy (p, p_c, s, P_r) in the case with corruption the net revenue does not exceed the net revenue under optimal strategy :

$(T/F, 0, s_{min}, 0)$[9] with no corruption. But this revenue in the case with corruption can be achieved with the strategy $(T/F, 0, s_{min},, F)$. Under this strategy the behavior of agents is the same and premiums are not actually paid.

3.4. Risk averse inspectors.

Consider again the case with two levels of income but now suppose that inspectors are risk averse. This is a reasonable assumption since inspector is typically a small entity and his salary is the only source of income for him. A taxpayer may be 'more risk-neutral' if it is a relatively solid enterprise[10] .

Suppose that an inspector is an expected utility maximizer with some concave utility function U. Denote again V_b and V_h the expected present discounted utility of an inspector when he accepts bribes and behaves honestly respectively. In the case inspector accepts bribes he gets $U(s)+(1-\delta)V_b$ if he does not meet an evader. Meeting with an evader gives him expected utility of :

$$U(b+s)+(1-p_c)(1-\delta)V_b + p_c[(1-\delta)/\delta]U(s_{min}).$$

Therefore, V_b meets the following recursion formula :

$$V_b=(1-\mu q)[U(s)+(1-\delta)V_b]+\mu q[U(b+s)+(1-p_c)(1-\delta)V_b + p_c[(1-\delta)/\delta]U(s_{min})].$$

(μ is the same "adjusted" share of evaders as in the previous sections). Then,

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[9] It is easily seen that this strategy is optimal if it gives the positive revenue: $R^*=qT/F-(1-q)(s+\underline{c})$. Otherwise this group of taxpayers is not worth audited. It is assumed, therefore, that $R^*>0$.

[10] A careful consideration of the case with risk-averse taxpayer would be also useful.

$$V_b = \frac{(1-\mu q)U(s) + \mu q U(b+s) + \mu q p_c \frac{1-\delta}{\delta} U(s_{\min})}{\delta + \mu q p_c (1-\delta)}$$

Honest behavior gives an inspector :

$$V_h = \frac{\mu q U(s+P_r) + (1-\mu q)U(s)}{\delta}$$

$V_b \geq V_h \quad \Leftrightarrow$

$U(b+s) \geq (1/\delta)\ [\delta+(1-\delta)](\mu q)p_c]U(s+ P_r)+\ [(1-\delta\ )/\delta]\ p_c[1--(\mu q))U(s)-U(s_{min})]$

This condition determines the minimal amount of bribe acceptable for inspector.

With $P_r=F$ the condition becomes :

$U(b+s) \geq\ U(F+s)+\ [(1-\delta\ )/\delta]\ p_c\ [(\mu q)U(s+F)+(1-(\mu q))U(s)-U(s_{min})]\ \ (*)$

The expression $(\mu q)U(s+F)+(1-(\mu q))U(s)-U(s_{min}) > 0$ because this is the inspector's participation constraint. Therefore, condition (*) can be satisfied only if $b \geq F$.

Thus, by $P_r=F$ corruption becomes unprofitable as in the case of risk neutral inspectors.

This observation enables to establish the similar result for the optimal strategy as in the case with risk neutral inspectors :

<u>Proposition 2'</u>. *If inspectors are risk-averse the same auditing strategy* $P_r = F$, $s= s_{min}$ $p_c = 0$, $p=T/F$ *is optimal.*

<u>Proof .</u> Show again that under any fixed probability of auditing *p* and fixed salaries for an inspector the net revenue of the tax authority with corruptible inspectors under any probability of reviewing and premiums can not exceed that in case of honest ones. (Now it is supposed that premiums are (optimally) not paid in the 'honest' case). The reason for that is mostly the same, with only difference that inspectors are now risk averse and the sum of utilities of all parties is not

constant. But note, that since there is no randomness in inspector's revenue in the 'honest case' his expected revenue in the 'dishonest case' cannot be smaller (by Iensen's inequality) (actually he receives at least the same s[11]). Taxpayers behave in the way, that gives them at least the same expected revenue. By noting again that the number of evaders does not fall[12], which means that the expenditures on salaries and other costs of auditing (and reviewing) are not smaller one concludes that the net revenue is not smaller in the 'honest case'. But again the maximal revenue for the 'honest case' is achievable with the strategy *(T/F, 0, s_{min},, F)*, since , as it was shown, this strategy wipes out corruption and therefore generates the same honest behavior.

4. OPTIMAL STRATEGY OF THE TAX AUTHORITY UNDER CONTINUOUS INCOME DISTRIBUTION.

In reality the income of taxpayers typically takes more than two values, therefore it is useful to consider a situation with continuous income distribution. Let it be distributed over the interval $[0, I_{max}]$, with some density function $v(I)$. The tax liability is represented by an increasing function $T(I)$. For now it is assumed to be linear : $T(I)= tI$. Each taxpayer with the true income I chooses some income report $I_d(I)$. The tax authority chooses the probability of auditing for each reported income, which is the function $p(I_d)$. An audit always reveals the true income of a taxpayer (as before each audit imposes some fixed cost). The fine for

[11] Suppose now that if fired inspector keeps his last salary.
[12] Again all taxpayers evade if $p<T/F$ in both cases. If $p \geq T/F$ nobody evades in the 'honest' case.

underreporting is the function $F(I,I_d)$, and includes unpaid tax. This function is assumed to be linear in unreported income: $F(I, I_d) = (t+f)(I- I_d)$.

First, suppose that all inspectors are honest by nature so that there is no bribing. In this case Sanches and Sobel (1993) (and Vasin, Panova (1998) for the case where I_{max} is a priory unknown and unbounded) show that the optimal auditing strategy $p^*(I_d)$ which maximizes the expected net revenue of the tax authority is either to audit all income reports with probability $\hat{p} = t/(t+f)$ or to audit only income reports below some threshold $\hat{I}$ with the same probability $\hat{p}$, which is the minimal probability of auditing necessary to make bribing unprofitable. Which strategy is optimal depends on the distribution of income and the parameters of the model.

An important aspect of this strategy is that under such rule tax authority does not actually impose fines, because taxpayers underreport only up to the point where their reports are not audited.

Now, suppose that, as in the model considered in previous sections, tax inspector may accept bribes from those who evade and conceal the results of auditing. If inspector encounters an evader who reported I_d which is below his true income I, then he has two possibilities. First, he can report the taxpayer's true income I to the tax authority whereby a taxpayer pays the fine $F(I, I_d) = (t+f)(I- I_d)$ and inspector gets some share of it as a premium. Another opportunity for a taxpayer and inspector is to collude. In this case inspector will agree to report $I_i < I$ to the tax authority for accepting a bribe in turn $(I_i \subset [I_d, I))$.

In this case there exists some probability p_c for an inspector of being exposed in shielding taxpayer's true income. Information about that may be obtained as the result of additional reviewings of inspectors, as in the previous section. In this case the probability of being exposed is controlled by the tax authority and in practice may depend on inspector's report I_i

Another situation is when the information about dishonest behavior leaks to the tax authority through some independent channels. In this case the probability p_c is exogenous. This approach is sometimes used in the literature on monitoring pollution (see. e.g. Mookherjee, Png (1995)).

In what follows, it will be assumed that p_c is controlled by the tax authority but does not depend on inspector's report I_i . This is similar to the approach of Keen, Hindriks, Muthoo (1998) (However, the ability of the tax authority to control p_c is not crucial for the main result established below.)

The fine for dishonest inspector is proportional to $(I- I_i)$ with some coefficient g.

Suppose, that premium to an inspector is a linear function of the fine :

$$Pr\,(I_i\,, I_d\,) = \alpha\,(t+f)\,(I_i - I_d\,),\ \alpha \subset [0,1].$$

In this case it is easy to see that if collusion is profitable, then inspector will always report $I_i = I_d$. To see this, note, that the joint gain G from collusion is a linear function of I_i :

$$G(I_i\,) = (t+f)(I- I_i\,)(1- p_c\,) - p_c\, g\,(I- I_i\,)- \alpha\,(t+f)\,(I- I_i\,).$$

The first term in this expression is the taxpayer's gain from lower fine payment. The second and the third terms are respectively inspector's expected loss from exposure and loss from unreceived premium. Taxpayer and inspector will collude if

$$G'(I_i\,)= p_c g +\alpha(t+f) -(t+f)(1- p_c\,)<0 \quad \text{or} \quad (1- p_c -\alpha)(t+f) > p_c\, g \qquad (8)$$

and in this case inspector will report $I_i = I_d$. Note, that profitability of bribing is wholly determined by the parameters set by the tax authority and does not depend on actual and reported incomes.

In the case when bribing is profitable it will be assumed, for simplicity, that the taxpayer and the inspector agree upon a bribe that balances their respective net gains[13]:

$$(t+f)(I- I_d)(1- p_c) - b = b - p_c g (I- I_d) - \alpha (t+f) (I- I_d).$$

The left-hand side is the gain for the taxpayer, the right-hand side is that for the inspector. This gives the value of bribe :

$$b = 0.5\{(t+f)(I- I_d)(1- p_c) + p_c g (I- I_d) + \alpha (t+f) (I- I_d)\}=$$

$$= 0.5\{ (t+f) (1- p_c + \alpha) + p_c g \} (I- I_d). \qquad (9)$$

(Now $b_{min} = (t+f)(I- I_d)(1- p_c)$; $b_{max} = p_c g (I- I_d) + \alpha (t+f) (I- I_d)$,

$b=(b_{min} + b_{max})/2$ $(\gamma=0.5)$ which again gives the above expression *(9)*).

As before the tax authority faces costs of auditing c consisting of inspector's salary s and some fixed cost $\underline{c}$ and cost of reviewing $\tilde{c}$.

The tax authority has a discretion over the probability of auditing $p(I_d)$. It also chooses the inspector's salary s, the rate of commission α, $\alpha \subset [0,1]$ and p_c . The aim of the tax authority is to maximize its net revenue. Taxpayer, observing these parameters decides what income to report.

Proposition 3. *The optimal strategy of the tax authority is to set the probability of auditing according to the cut-off rule $p^*(I_d)$, that is to audit only income reports below $\hat{I}$ with probability t/(t+f). (The value of $\hat{I}$ is the same as in the solution for intrinsically honest inspectors). Then, it should pay the whole fine for underreporting as the premium, set the salary at the inspector's reservation*

[13] Formally, this is the Nash bargaining solution where each party has equal bargaining power. The results would not change substantially if the parties have unequal bargaining power.

level. No reviewing is necessary. That is the optimal strategy is : $p(I_d) = p^*(I_d)$, $p_c = 0$, $\alpha = 1$, $s = s_{min}$.

The proof of this proposition is given by the same arguments as in the proof of proposition 2. One should only make sure that the behavior of the taxpayers in the case of corruptible inspectors is such that the cost of auditing does not decrease. To establish this it is sufficient to show that the new report of the taxpayer is such that the probability of auditing for this report is not less than for the report he chose in the situation with no corruption. This is done by the following lemma.

Lemma *Let* I_d *be the optimal report of a taxpayer in the situation with honest inspectors for some fixed rule of auditing and* $\underline{\tilde{I}_d}$ *be the optimal report of the same taxpayer and under the same rule* $p(I_d)$ *in the situation with corruptible tax inspectors,* $I_d \neq \underline{\tilde{I}_d}$. *Then* $p(I_d) \leq p(\underline{\tilde{I}_d})$.

Proof of the lemma..

A taxpayer chooses his report to maximize his expected net benefit from underreporting. If there is no corruption the taxpayer maximizes

$$B(I_d) = t(I - I_d) - p(I_d)(t+f)(I - I_d).$$

The two reports may differ only in the case when bribing is profitable, therefore assume that the condition *(8)* is satisfied. In the situation with corruption the net benefit from underreporting is, if bribing is profitable :

$$\tilde{B}(I_d) = t(I - I_d) - p(I_d)\,(b(I, I_d) + p_c\,(t+f)(I - I_d))$$

where $b(I, I_d)$ is given by *(9)*. For any $I_d < I_d^*$ $p(I_d)$ is greater than $p(I_d^*)$ because otherwise it would be optimal for the taxpayer to lower his report .

Therefore, suppose that $I_d^* < \underline{\tilde{I}_d}$. Optimality of $\underline{\tilde{I}_d}$ in the 'dishonest case' implies that $\tilde{B}(\underline{\tilde{I}_d}) \geq \tilde{B}(I_d^*) \quad \Leftrightarrow$

$$t(I-\underline{\tilde{I}_d}) - p(\underline{\tilde{I}_d})\,(b(I,\underline{\tilde{I}_d}) + p_c\,(t+f)(I-\underline{\tilde{I}_d})) \geq t(I-I_d^*) - p(I_d^*)\,(b(I,I_d^*) + p_c(t+f)(I-I_d^*))$$

Substituting the expression for b from *(9)* after simple manipulations one gets :

$$t(\underline{\tilde{I}_d} - I_d^*) \leq \beta\,(p_c)\{\,p(I_d^*)(I-I_d^*) - p(\underline{\tilde{I}_d})\,(I-\underline{\tilde{I}_d})\} \qquad (10)$$

where $\beta(p_c) := 0.5\{\,(t+f)\,(1-p_c+\alpha) + p_c g\} + p_c(t+f)$

Optimality of I_d^* in the 'honest case' implies that $B(I_d^*) \geq B(\underline{\tilde{I}_d}) \quad \Leftrightarrow$

$$t(I-I_d^*) - p(I_d^*)(t+f)(I-I_d^*) \geq t(I-\underline{\tilde{I}_d}) - p(\underline{\tilde{I}_d})(t+f)(I-\underline{\tilde{I}_d}) \quad \text{which gives}$$

$$t(\underline{\tilde{I}_d} - I_d^*) \geq (t+f)\,\{p(I_d^*)(I-I_d^*) - p(\underline{\tilde{I}_d})(I-\underline{\tilde{I}_d})\} \qquad (11)$$

From *(10)* and *(11)* one gets

$$\beta\,(p_c)\{p(I_d^*)(I-I_d^*) - p(\underline{\tilde{I}_d})\,(I-\underline{\tilde{I}_d})\} \geq (t+f)\,\{p(I_d^*)(I-I_d^*) - p(\underline{\tilde{I}_d})(I-\underline{\tilde{I}_d})\} \quad or$$

$$p(\underline{\tilde{I}_d})\,(I-\underline{\tilde{I}_d})\,[t+f-\beta(p_c)] \geq p(I_d^*)(I-I_d^*)[t+f-\beta(p_c)]$$

Note, that $t+f-\beta(p_c)>0$ which follows from the condition of the profitability of bribing *(8)*.

Then,

$$p(\underline{\tilde{I}_d})\,(I-\underline{\tilde{I}_d}) \geq p(I_d^*)(I-I_d^*) \qquad (12)$$

Since we assumed that $I > \underline{\tilde{I}_d} > I_d^*$ the above inequality implies that $p(\underline{\tilde{I}_d}) > p(I_d^*)$ with necessity Q.E.D.

It was supposed that p_c does not depend on inspector's report. However, at least theoretically, the tax authority could condition its reviewing strategy on inspector's report. Also it could apply a non-linear scheme of premiums. It can be shown, that in this case the tax authority can establish such rule $p_c(I_i)$ that evaders will switch to new reports $\tilde{I}_d$ such that the probability of auditing and therefore auditing costs would decrease ($p(I_d*) > p(\tilde{I}_d)$). Under this more flexible strategy one should investigate the behavior of agents much more deeply. Therefore the result about optimal strategy in such general situation may be formulated only as a hypothesis.

Hypothesis . The tax authority cannot obtain higher net revenue than it can get with honest inspectors if it can use non-linear commission (premium) rule and condition the probability of reviewing on inspector's report.

5. CONCLUSION.

The main idea of this master thesis is to illustrate the important role of giving incentives to tax inspectors. Tax officers charged with auditing income reports from taxpayers may have little incentive to behave in the interest of their principal, the central tax authority, and accept bribes from dishonest taxpayers..

However, the tax authority can in turn "bribe" an inspector itself by paying him as a premium some share of fines he or she collects. If such policy is announced, it may improve not only incentives of the inspectors to work honestly but also affect those of taxpayers to reduce evasion. The reason for that is that they become aware of the generic honesty of their supervisors and do not expect the possibility of paying a small bribe instead of fine. In the framework considered in the paper it turns out to be optimal to let inspector to take the whole fine as commission. This helps to eradicate corruption and gives the possibility to attain the same maximal revenue as in the case with intrinsically honest inspectors.

Of course, the model used here is highly stylized. It is widely believed that taxpayers exposed in tax evasion along with fines bear additional inconvenience (this aspect is an important feature of the model of Chander, Wilde (1992)). This additional burden may differ across the taxpayers which could significantly smear a nice picture of agents‘ behavior (fig.1). Another aspect missing from the model is the effort of an inspector which he has to put in his work. In practice audits reveal the taxpayer’s true income only with some probability, which essentially depends on the effort of the inspector (see e.g. Mookherjee, Png (1995)). If evasion is reduced tax inspectors do not expect to get much premiums and therefore may start to work not too hard. Therefore the effect of increasing premiums is rather ambiguous in this case. Finally, increasing premiums may give rise to extortion (see Vasin, Agapova (1993), Keen, Hindriks, Muthoo (1998)). If the judicial system is not too strong, which seems to be the case of Russia, the tax inspector has a small risk of being exposed over-stating the taxpayer’s true income, which gives him higher commission (this motive was introduced in Keen, Hindriks, Muthoo (1998)) .

The above notes suggest some important directions for the future research in this field. In conclusion, I wish to express special thanks to my scientific advisor Professor Alexander Vasin for useful recommendations and stimulating discussions.

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APPENDIX

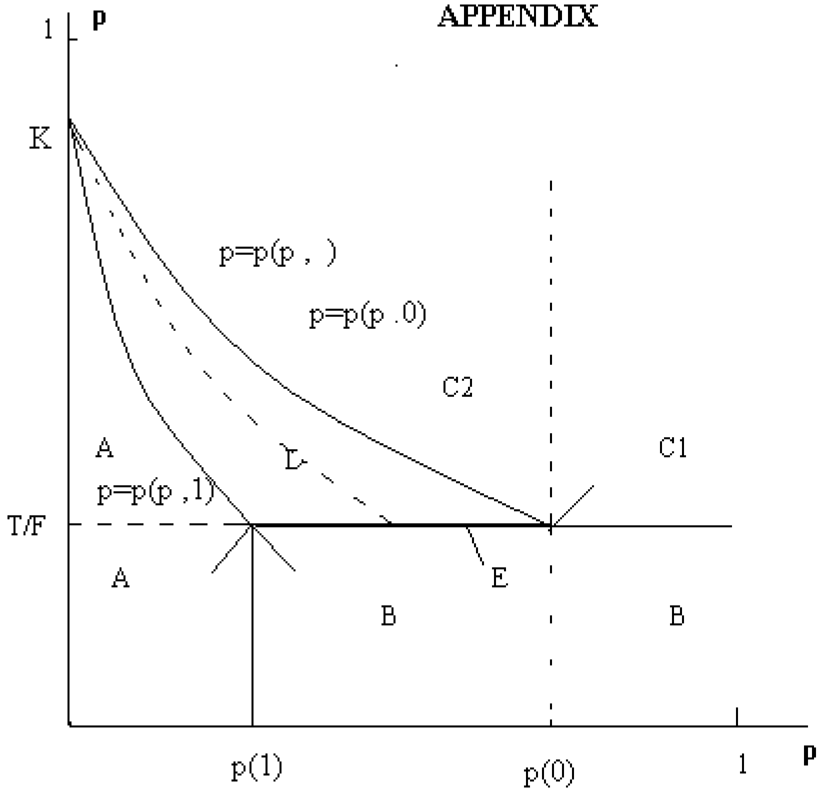

fig.1