Application Costs and the Design of Licensing Procedures

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Abstract

License procedures are a common way of enforcing regulation of activities whose effects on social welfare depend on the specificities of the single case. Building permits may serve as an example, but many other licensing procedures follow the same structure. In particular in Germany, the long duration of such procedures and the low predictability of their outcomes have been identified as a major obstacle to economic progress. As a consequence, the German legislators have invoked legislation to accelerate the procedure. This paper investigates how the acceleration approaches affect not only the costs of citizens who already filed an application but also how influence decisions on whether to apply and what projects to plan. I will show that acceleration may have unintended side effects which may more than offset the increase in welfare gained by lower application costs. I will also show that deterrence of applications based on illegal project need not be a better alternative: it may be impossible not to deter the legal projects as well.

Keywords: Regulation, Licensing Procedures, Administration Costs, Over-Deterrence, Applied Game Theory

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1 Introduction

Regulatory regimes usually aim at the solution of conflicts between private and social interests due to externalities. The goal is to avoid welfare decreasing (and therefore illegal) modes of the regulated activity without hindering welfare increasing (and therefore legal) modes of the activity. In many cases, application of the regulation to specific cases relies on an administrative process in which a permission to perform the regulated activity is granted, or denied, after someone applied for such permission and the administration investigated whether the applicant's plans deserve permission. An example for such regulation is zoning law which is, in most industrialized countries, enforced by the requirement of a government permission before construction starts (or at least before the new building may be used).

In many countries, this administrative procedure itself —and not the correctness of its outcome— has been identified as a major obstacle to private investments and economic growth: the procedure is so time and resource consuming that many viable, welfare enhancing acts are omitted only for the costs of the application procedure. In Germany, the reaction to this insight was the introduction of administrative acceleration legislation. The goal of this legislation was to increase the number of applications for example for building permits in order to increase socially valuable production in the construction industry. Many German Länder address this problem by legally limiting the time between the filing of an application and the administrative decision.

This proposal neglects the interaction between the number of applications and the time administrators need to hand down a decision on an application: the more applications there are, the longer it takes until a specific case is decided upon; the less applications there are, the shorter any case has to wait. In addition, feedback loops between the proportion of application which legally merit permission and the willingness of administrators to grant permission if their information is inconclusive should be taken into account.

In this paper I develop a model of administrative adjudication on applications for permissions and of citizens' decisions whether to file an application and comply with the regulations or file an application and take the risk of violating the regulations or not to file at all. Based on this model, I will study the effects of accelerating the administrative procedure by restricting the time the administration may take to hand down its decision. I will compare the effects of this approach with fines for applicants whose permission is denied and who are thus assumed to have had a plan violating the regulations. The following section gives a brief overview of the literature on administrative procedure, including the literature on tax evasion and auditing. The next section introduces the inspection game as a starting point for modeling administrative procedure. Section 4 extends the inspection game and develops the central model of the paper. Then sections on applications and on variations of the model follow. Section 7 concludes.

2 Administrative Procedure in the Literature

Administrative procedure and in particular rules on administrative procedure aim at overcoming principal-agent problems between the legislative and the executive branch of the state, as well as within the executive branch. The literature dealing with these principal-agent problems is divided into three relatively independent branches. The first is the literature on legislative control of bureaucratic rule making. The second is part of the standard formal principal-agent literature aiming at designing optimal incentive mechanisms. The third one is more directed towards the interaction between citizens and administrators and is subdivided into two parts: the literature on tax evasion and auditing and the literature on incomplete criminal enforcement with endogenous enforcement probabilities.

The literature on legislative control of bureaucratic rule making is mainly positive. It originates from the positive political theory, whose research program concentrates on the interaction of different institutions in the political process. The main goal of this legislative control literature is to show that administrative procedure is a way to bind administrative bureaucracies to the deal between different political institutions and interest groups in the legislative process: rules on administrative procedure allow different interest groups to interfere with the process of administrative rule making which fills the gaps left in the legislative process (e.g. McNollgast (1987, 1989, 1999), Moe (1987, 1989), and Eskridge and Ferejohn (1992); for an overview see von Wangenheim (1999)).

Within the formal principal-agent literature, some authors concentrate explicitly on public administrations. As is usual for the formal principal-agent literature, these authors search for solutions in the design of optimal incentive mechanisms in an abstract way. This branch of the literature on administration-related principal-agent problems had originally been developed for studying hierarchies *within* bureaucracies (e.g. Tirole (1986)). However, the focus of this line of research soon moved to studying optimal incentive mechanisms for or by government agencies which are modeled as unitary actors, e.g. Laffont and Tirole (1990)) or by, Laffont and Tirole (1993). Only lately has this branch of study returned to questions related to hierarchies internal to public administration Tirole (1994). The papers of Holmstrom and Milgrom (1991), of Gabel and Sinclair-Desgagné (1993) and of Itoh (1994) deal with a problem which is of particular relevance to mass adjudication by public authorities: principal-agent relationships in which the agent has to perform multiple tasks for which control is incomplete and where some tasks are easier to control than others. The tasks of single case adjudicators in administrations are of exactly this kind: they have to avoid false permissions as well as false denials of permission, and at the same time hand down a large number of decisions. While the number of decisions handed down is easy to control, the difficulties in controlling the other two tasks depends on who is willing to challenge false decisions of either type, and to what degree. Unfortunately, all these papers assume production functions of the agent(s) as given. They fail to take administrative procedure as perhaps the most important determinant of the shape of the production function into account explicitly. Their goal is to develop optimal incentive mechanisms in a rather abstract way. Again, this literature is of limited use for understanding the effect of rules on administrative procedure.

The interaction of citizens applying for a license and administrative adjudicators has some similarities to the interactions described in the third branch of economic literature dealing with principal-agent problems related to public administration: the literature on tax-evasion and auditing (seminal: Graetz, Reinganum and Wilde (1986) and Reinganum and Wilde (1986); for an overview on this literature see Andreoni, Erard and Feinstein (1998)). The basic idea of these approaches with respect to the interaction between tax payers and tax authorities is the following: tax authorities audit only some fraction of all tax returns, the remainder is accepted as filed. The authorities decide on the size of the fractions of tax returns which will be audited, typically as a function of the incomes stated by the tax payer. Tax authorities can either commit to specific audit fractions or at least to a total audit activity, determined by the budget and the per audit costs. If auditing is performed, it is perfect and per audit costs are constant. Tax authorities are typically assumed to maximize tax plus fines revenue.

Related to this approach is the literature on incomplete criminal enforcement with endogenous enforcement probabilities. I will mention some articles of this branch of literature when I introduce the inspection game in the section to follow immediately.

3 The Simple Inspection Game

3.1 Structure and Equilibria of the Game

The inspection game is the two-by-two simultaneous game widely used in game thoery to describe problems of asymmetric information which a supervisor may get complete information by some investment but cannot further alter the incentive structure of the agent. Depending on the field of application, the game appears under different names, but always has the same structure. Under the label "enforcement game" the game is used to describe a policeman's problem to control a potential offender (Holler (1993), Tsebelis (1989, 1993));[1] under the label "welfare game" it is used to describe an administration which is supposed to support unemployed workers if and only if they are searching for employment and an unemployed worker who searches for employment only if she does not receive unemployment benefits (Tullock (1983: 59), Rasmusen (1994: 68)). The name inspection game is borrowed from Fudenberg and Tirole (1992: 17). The structure of the game is similar to that of "matching pennies" in which one player wins if both players announce head or both announce tail while the other wins if thier announcements differ from each other.

With reference to the licensing procedure, the game is best described as follows. A citizen "C" applying for a permission may either choose an action s_c which complies with the regulations requiring the permission and therefore entitles him to the permission, or he can choose an action s_v which violates the regulations and therefore is not eligible for the permission. The other player, an administrator "A", is ignorant of what action the applicant has chosen and can either grant permission without investigating (or "inspecting", whence the name of the game) the case (s_g), or investigate the case and grant permission if and only if the investigation yielded that the plan is legal (s_i). Investigation yields complete information on the applicant's plan.

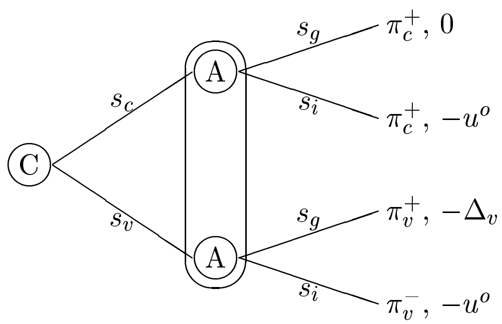
If the citizen gets permission for the legal plan, his payoff is positive (π_c^+). If he gets

[1] Philipson and Posner (1996) implicitely use a similar game in their section on the dynamics of the epidemiology of crime and self protection. Without refering to Philipson and Posner (1996), Cressman et al. (1998) use the same game to discuss the interaction of private protection from crimes and activity by criminals. They derive the same continuously circular dynamic.

permission for the illegal plan, his payoff is even higher ($\pi_v^+ > \pi_c^+$). The intuition behind the latter assumption is that state enforcement of regulation only makes sense, if there is a conflict between private preferences and the legal requirements defined by the regulation. If permission is denied (which can only happen if his plan was illegal), his payoff is smaller than for the permitted legal plan ($\pi_v^- < \pi_c^+$).[2]

If the administrator grants permission without investigation and the applicant's plan violates the regulation, she gets punished by the amount Δ_v.[3] If she grants permission without investigation and the applicant's plan complies with the regulation, her decision is correct, the resulting payoff is normalized to zero. If the administrator investigates the case, her decision is never wrong but she has to exert effort which costs her the disutility $u^o \in (0, \Delta_v)$.[4]

Figure 1 presents the game in extensive form and in matrix form.



		A	
		s_g	s_i
C	s_c	$\pi_c^+, 0$	$\pi_c^+, -u^o$
	s_v	$\pi_v^+, -\Delta_v$	$\pi_v^-, -u^o$

Figure 1: The standard inspection game: $\pi_v^+ > \pi_c^+ > \pi_v^-$, $\Delta_v > u^o > 0$. Payoffs are given for (applicant, administrator).

In this simple standard version of the game, exactly one Nash equilibrium results. The unique Nash equilibrium is in mixed strategies and is given by

$$p_c = p_c^* = \frac{\Delta_v - u^o}{\Delta_v} \qquad \text{and} \qquad q_i = q_i^* = \frac{\pi_v^+ - \pi_c^+}{\pi_v^+ - \pi_v^-}, \tag{1}$$

where p_c denotes the probability that the applicant plans to perform the regulated activity in compliance with the law, q_i denotes the probability with which the administrator investigates the case, and the asterisk marks the Nash equilibrium values.

Of course, questions arise whether this simple 2×2 version of the inspection game is an appropriate picture of the licensing procedure. It may be an appropriate model of the phenomena discussed in the literature mentioned earlier. It is, however, not sufficient to study the effects of policy changes in administrative procedure on the quantity of a regulated activity. The possibility of abstention from performing the activity at all is excluded by assumption. The central goal of reforms in the administrative procedure,

[2] Assumptions on the payoff in case of denial when the applicant had a legal plan will be introduced when relevant.

[3] The index of Δ_v denotes that the punishment is for the wrong decision on a plan violating the regulation.

[4] With $u^o \geq \Delta_v$, the administrator would never investigate.

however, is to expand the regulated activity. The assumption behind this goal is that the mere costs of filing an application and going through the permission procedure (which may take a long time and thus costs substantial interest) prohibit a fair amount of socially valuable activity. Without including the possibility of abstention in the game, neither can one study the effect of policy changes on the quantity of the regulated activity nor is it possible to investigate the welfare effects of an increase in the regulated activity.

In the same vein, it is at least doubtful whether a model in which administrators choose between just two options — permit without investigation or permit if and only if investigation of the case indicates legality — is reasonable. On the one hand, administrators might be willing to deny the permission without investigation, if that corresponds with their incentives most. On the other hand, reasonable assumptions on administrators would allow them to investigate the single cases at different degrees with decreasing returns to the intensity of the investigation: the more an administrator investigates a case, the less will her additional gain in reliability be.

4 Including The Possibilities of Abstention and of Rejection Without Investigation

4.1 Abstention

So far, the model is too restricted to capture the effects of alternative procedural rules in administrative procedure. Unlike tax evasion and crimes, private decisions on a regulated activity are trichotomous instead of dichotomous — it may not only be committed or not but can be performed in the legal way, in the illegal way or not at all. In terms of the game described in figure 1 this results in a third action s_a added to the choice set of the citizens: "abstain from planning the activity and from applying for a permission". By p_a I denote the probability that a citizen chooses this action and by $p_v = 1 - p_c - p_a$, the probability that he files an application based on an illegal plan. The payoffs for a citizen abstaining are zero independently of how the concerned administrator would behave if the citizens *would* file an application. Similarly, the payoff of the concerned administrator is zero, because she cannot exert effort on the unfiled application and cannot be sanctioned for a wrong decision.

With the alternative of abstention, the costs of filing an application will become relevant for the citizen. In the political discussion on the need to reform the administrative licensing procedure costs of filing an application are mainly attributed to the duration of the procedure. I therefore assume that the costs of filing an application is a (linear) function of the duration of the procure. Expected duration, in turn, depends on how much time administrators spend on an application on average and on the time an application has to wait while the concerned administrator is busy with other applications.

This requires to place the inspection model into a framework which deals with time explicitly. The latter is established in the following way. Assume that each citizen enters a situation (call it an "applications situation") at a random point in time in which he may decide to file an application or not, and if he files whether he wants to base his application on a legal or an illegal plan. Whenever a citizens files an application, one of a number of identical administrators is selected to decide on this application, with the way in which the selection takes place not being predictable to the applicant (this assumptions excludes reputation on the side of administrators) and allocating the same expected number of applications to each administrator. For each administrator, the inflow of applications into his queue of yet undecided applications is thus a sequence of events randomly distributed over time. In the most simple case, one might want to assume that the time between two consecutive application situations follows an exponential distribution,[5] but such a restriction is not necessary. To simplify the following argument I choose the standard time period so that on average there is one application situation per administrator within each time period.

Administrators on the other hand may randomly vary the time they take to decide on any particular application — in the main model of this paper this will be a binomial distribution (applications may be decided upon with zero or one specific strictly positive level of effort), in variations of the model other distributions will result.

These assumptions place the inspection game into a typical queuing framework. Borrowing from the general insights of queuing theory, I therefore assume that the expected waiting time $w(\cdot)$ — i.e. the time which an application has to wait after its filing until the concerned administrator starts to work on it — increases in the number of applications filed per standard time period and in the average time an administrator takes to hand down a decision on an application and furthermore increases hyperbolically in the product of these terms approaching infinity when the product grows towards one. The intuition behind the latter assumption is simple: suppose the product were equal to one, i.e. the administrator would be able on average to process as many applications as are filed as long as he is never idle. However, since the inflow of applications is random and independent of the current length of the waiting queue there is a strictly positive probability that the administrator becomes idle at any point in time and remains idle for some time. Hence, the expected idle time per calendar time period is strictly positive. Due to these idle times, the administrator is *not* able to process as many applications as are filed. The expected waiting must grow ever larger in the course of time.

Further, one should note that the waiting time approaches zero as the time the administrator spends on each application or — more important — the number of applications per time period decline towards zero. In the latter case (close to zero applications per time period), the duration of the administrative licensing procedure converges to merely the average time the administrator spends on an application. One can combine all these insights on the expected waiting time as follows:

$$\frac{\partial w}{\partial (p_c + p_v)} > 0, \quad \frac{\partial w}{\partial q_i} > 0, \quad \frac{\partial w}{\partial (p_c + p_v) q_i} > 0 \tag{2}$$

$$\lim_{(p_c+p_v)q_i \to 1} w(\cdot) = \infty, \quad \lim_{(p_c+p_v) \to 0} w(\cdot) = 0 \tag{3}$$

[5] Note that this would also imply an exponential distribution of the time between two consecutive filings of an application with a specific administrator unless applications are distributed among administrators according to criteria which depend on the length of the waiting queues of applications with the administrators.

Finally, one should keep in mind that more variables and parameters enter the function determining the expected duration of the licensing procedure. Most important are the type of the distributions of the time between two consecutive application situations and of the time the administrator spends on an application, as well as any information on recent lengths of the waiting queue. However these variables and parameters do not interfere with the quality of the functional relationships described so far. In addition, the steady state expected waiting time, i.e. the waiting time one may expect when the influence of historic queue lengths vanishes, is most relevant for equilibrium analyses, to which I will pay most attention in this paper.

Based on these arguments, I will write the costs of filing an application as:

$$k = k^o + c \cdot (q_i \tilde{e} + w(p_v + p_c, q_i \tilde{e}; \cdot)) \tag{4}$$

where k^o and c are strictly positive constants, $\tilde{e} > 0$ is the time spent on applications investigated, and $w(p_v + p_c, q_i \tilde{e}, \cdot)$ is the expected waiting time with the dot as third argument representing further variables and parameters as mentioned in the previous paragraph.

4.2 Rejection without investigation

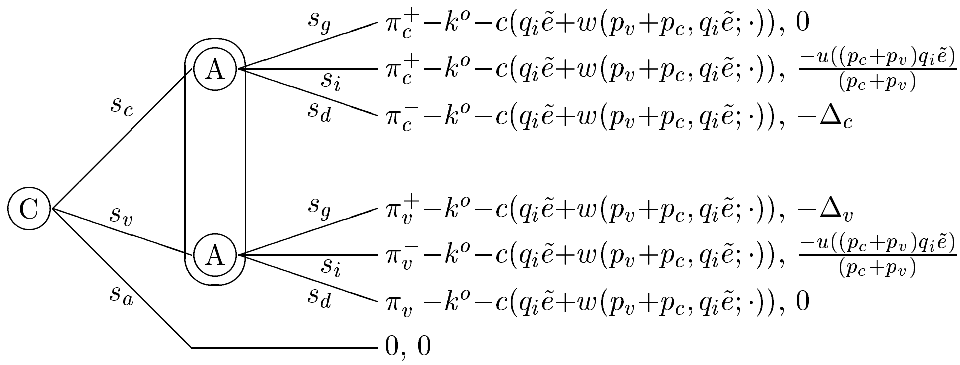
The existence of a third possible action of the citizens allows to extend the action set of the administrators in an intuitive way: there is no convincing argument why administrators who do not investigate a case should be restricted to granting the permission. They could equally well deny the permission if they do not know anything on the single case. Whether they will deny or grant depends, of course on the expected sanctions attributed to both alternatives.

I thus assume that the action set of the administrators includes the action s_d ("deny the permission without investigating the single case") in addition to the actions s_g (grant) and s_i (investigate). Denying permission to an illegal plan results in no sanction while denying to a legal plan results in an expected sanction of Δ_c.

In order to avoid linear dependence of the equations describing the optimization of administrators, and because it is more intuitive I assume that the marginal disutility of investigative effort is not constant (as it was in the simple inspection game) but increases in the number of applications investigated.

I will therefore replace the term u^o by $u((p_c + p_v) q_i \tilde{e})/(p_c + p_v)$ as the disutility of investigative effort per investigated application, where $u(\cdot)$ is an increasing concave function. To avoid corner solutions without any investigation I assume $\tilde{e} u'(0) < \frac{\Delta_c \Delta_v}{\Delta_c + \Delta_v}$ which corresponds to the earlier assumption $u^o < \Delta_v$. The game matrix the takes the form as depicted in figure 2. [6]

[6] Rasmusen (2001) uses a similar model to describe negotiation (not: bargaining) problems in which one party can offer a sincere contract clause, a misleading contract clause or no contract clause, while the other party can accept, reject, or investigate the offered clause.



		A		
		s_g	s_i	s_d
	s_c	$\pi_c^+ - k$, 0	$\pi_c^+ - k$, $\frac{-u((p_c+p_v)q_i\tilde{e})}{(p_c+p_v)}$	$\pi_c^- - k$, Δ_c
C	s_v	$\pi_v^+ - k$, $-\Delta_v$	$\pi_v^- - k$, $\frac{-u((p_c+p_v)q_i\tilde{e})}{(p_c+p_v)}$	$\pi_v^- - k$, 0
	s_a	0, 0	0, 0,	0, 0

$$k = k^o - c(q_i\tilde{e} + w(p_v+p_c, q_i\tilde{e}; \cdot)).$$

Figure 2: Extended inspection game; $\pi_v^+ > \pi_c^+ > \pi_c^- \geq \pi_v^-$. Payoffs are given for (applicant, administrator).

4.3 Equilibrium Analysis

Let $\bar{q}_i$ and $\bar{q}_g$ be the administrators' average probability to investigate a case and to grant permission without investigation, respectively. Define the expected payoffs of a citizen as

$$\mathrm{E}V_c \equiv (\bar{q}_g + \bar{q}_i)\pi_c^+ + (1 - \bar{q}_g - \bar{q}_i)\pi_c^- - k^o - c(q_i\tilde{e} + w(p_v+p_c, q_i\tilde{e}; \cdot)) \tag{5}$$

and

$$\mathrm{E}V_v \equiv \bar{q}_g\pi_v^+ + (1 - \bar{q}_g)\pi_v^- - k^o - c(q_i\tilde{e} + w(p_v+p_c, q_i\tilde{e}; \cdot)) \tag{6}$$

if he files an application based on a legal or an illegal plan, respectively, and $\mathrm{E}V_a \equiv 0$ if he abstains. Finally, define the expected utility of an administrator as a function of her probabilities to investigate a case and to grant or deny permission without investigation as

$$\mathrm{E}U(q_i, q_g, q_d) \equiv -u((p_c + p_v)q_i\tilde{e}) - p_c\Delta_c q_d - p_v\Delta_v q_g \tag{7}$$

and the first partial derivatives thereof as $\mathrm{E}U_i = -(p_c+p_v)\tilde{e}u'((p_c+p_v)q_i\tilde{e})$, $\mathrm{E}U_g = -p_v\Delta_v$, and $\mathrm{E}U_d = -p_c\Delta_c$.

Then a strategy profile is a Nash equilibrium for this game if and only if

$$(\mathrm{E}V_k - \mathrm{E}V_l)p_k \geq 0 \quad \forall k, l \in \{c, v, a\} \tag{8}$$

and

$$(\mathrm{E}U_k - \mathrm{E}U_l)q_k \geq 0 \quad \forall k, l \in \{i, g, d\} \tag{9}$$

The game may have multiple equilibria, in particular if the constant term k^o in the application costs is sufficiently large. Before determining the complete set of Nash equilibria, I state some preliminary results to facilitate the remaining argument.[7]

Lemma 1 *The set of Nash equilibria of the extended inspection game includes*

1. *no element with* $p_c^* > p_v^* = 0$,
2. *no element with* $p_v^* > p_c^* = 0$,
3. *no element with* $p_v^* + p_c^* > 0$ *and* $q_g = 0$ *or* $q_g = 1$ *for all administrators,*
4. *no element with* $p_v^* + p_c^* > 0$ *and* $q_i = 0$ *for all administrators,*
5. *a connected set with* $p_c^* = p_v^* = 0$, $\bar{q}_g^* \leq \min\left(\frac{\bar{q}_i^* c\tilde{e}+k^o-\pi_v^-}{\pi_v^+-\pi_v^-}, \frac{\bar{q}_i^*(c\tilde{e}-\pi_c^++\pi_c^-)+k^o-\pi_c^-}{\pi_c^+-\pi_c^-}\right)$ *unless* $k^o < \min(\pi_c^-, \pi_c^+ - c\tilde{e})$.

Note that the connected set of Nash equilibria is only defined up to the average behavior of the administrators. Also note that the non-existence of a Nash equilibrium with $p_v^*+p_c^* > 0$ and $q_i = 0$ (case 4 of the lemma) is an artefact resulting from the assumptions on $u(\cdot)$. However, equilibria without any investigation are of little interest for the study of the effects of the duration of licensing procedures.

Of more relevance for a policy analysis are Nash equilibria with strictly positive application numbers. The following proposition deals with this type of Nash equilibria.

Proposition 1 *Besides the possibly existing connected set of Nash equilibria described in lemma 1, the extended inspection game exhibits at least one "interior" Nash equilibrium with strictly positive application numbers if and only if* $k^o < \pi_c^+ - \frac{\pi_v^+-\pi_c^+}{\pi_v^+-\pi_v^-}c\tilde{e}$. *The set of interior Nash equilibria is identical to the set of quadrupels* $(p_c, p_v, q_i, \bar{q}_g)$ *which satisfy the following two pairs of conditions:*

$$\bar{q}_g = \frac{(\pi_c^+ - \pi_c^-)q_i + \pi_c^- - \pi_v^-}{\pi_v^+ - \pi_c^+ + \pi_c^- - \pi_v^-} \leq \frac{\pi_c^+ - \pi_v^-}{\pi_v^+ - \pi_v^-} \tag{10a}$$

$$\tilde{e}u'((p_c + p_v)q_i\tilde{e}) = \frac{p_v\Delta_v}{p_c + p_v} \leq \frac{\Delta_c\Delta_v}{\Delta_c + \Delta_v} \tag{10b}$$

and

$$p_c + p_v \leq 1 \tag{11a}$$

$$0 \leq q_i\frac{(\pi_c^+ - \pi_c^-)(\pi_v^+ - \pi_v^-)}{\pi_v^+ - \pi_c^+ + \pi_c^- - \pi_v^-} + \frac{\pi_v^+\pi_c^- - \pi_c^+\pi_v^-}{\pi_v^+ - \pi_c^+ + \pi_c^- - \pi_v^-} - k^o - c(q_i\tilde{e}+w(p_v+p_c, q_i\tilde{e}; \cdot)) \tag{11b}$$

where the strict inequalities are mutually exclusive within each pair of conditions.

[7] Rasmusen (2001) derives similar, though unnecessarily restrictive conditions which Nash equilibria must satisfy.

Note that the proposition defines the Nash equilibria only with respect to the *average* probability that administrators permit without investigation, while the equilibrium level of the probability to investigate is defined for every administrator (at the same level due to the assumption of identical administrators). The reason is that the q_g enter the equilibrium conditions only via the optimization of the citizens who cannot differentiate between administrators and therefore only care for their average behavior. The level of q_i, on the other hand, enters the expected utility of each administrator in a nonlinear way. As a consequence, each administrator chooses the same interior optimum of q_i.

Also note that the existence condition $k^o < \pi_c^+ - \frac{\pi_v^+ - \pi_c^+}{\pi_v^+ - \pi_v^-} c\tilde{e}$ is less strict than the non-existence condodion in part 5 of lemma 1: $\pi_c^+ - \frac{\pi_v^+ - \pi_c^+}{\pi_v^+ - \pi_v^-} c\tilde{e} > \pi_c^+ c\tilde{e}$. The interior Nash equilibrium and the connected set of Nash equilibria with $p_c + p_v = 0$ thus may, but need not co-exist. Depending on the parameters only one or only the other may exist.

To facilitate the discussion of different policy approaches aiming at the acceleration or the improvement of the administrative licensing procedure, figure 3 gives a sketch of the graphs of the functions defined by (10b) and (11b) (both interpreted as equalities) in the $(q_i, p_c + p_v)$–space. Three cases of Nash equilibria are depicted:[8]

(a) the case of $q_d > 0$ and $p_a > 0$, i.e. strict inequalities in both (10a) and (11a)

(b) the case of $q_d > 0$ and $p_a = 0$, i.e. strict inequality in (10a) and equality in (11a)

(c) the case of $q_d = 0$ and $p_a > 0$, i.e. equality in (10a) and strict inequality in (11a)

Case (a) is defined by the intersection of the functions defined by the equalities (10b) and (11b). Note that there may be more than one intersections of these functions. However, one can show that intersections for which (10b) is below (11b) to the left of the intersection and above (11b) to the right, are unstable equilibria under any reasonable dynamic even if

[8] The graph is based on the following parameters: $\pi_v^+ = 30$, $\pi_c^+ = 20$, $\pi_c^- = 17$, $\pi_v^- = 15$, $c = 0.5$, $k^o = 18$, $\tilde{e} \in \{1.8, 2.2\,3\}$, and $u'(0.35\tilde{e}) = \frac{\Delta_c \Delta_c}{\Delta_c + \Delta_v}$. The last expression implies that different parameters do not directly affect the incentives of the administrators: $(p_c + p_v)q_i = 0.35$ for all values of $\tilde{e}$. If the three cases represent the result of different policies then this means that the policy differences do not directly affect the administrators' incentives to exert effort, but only influence how this effort transforms in waiting time. The different policies could for example be different numbers of administrators per citizen. Note that the parameter π_v^+ differs much more from the other expected payoffs than these differ from each other. This is required for a reasonably large upper limit of q_i. The model canot explain why casual experience does not show such large differences of π_v^+ from the other expected payoffs but nevertheless shows large inspection rates (or is this just wishful thinking?). Formally, $\pi_v^+ - \pi_c^+ = \frac{q_i^{\max}}{1 - q_i^{\max}}$, i.e. when q_i gets close to one, then π_v^+ must differ extremely from the other expected payoffs. Note that this problem is *not* related to the assumptions on the administrators' incentives except that administrators direct incentives to exert effort must not be so strong that they stick to a very high effort even if no illegal applications are filed. Note that such strong direct incentives would imply zero illegal plans, which again contradicts casual experience. Perhaps the possibility of zero *deliberately* illegal plans works. Then the game would then be of the Hafner-type: administrators know that all applicants try to file with legal plans, the only problem is to find out what is legal. The problem is also unrelated to the costs of filing an application. It might vanish with the assumption of heterogeneous citizens. Probably not: all applicants for whom $\pi_v^+ - \pi_c^+ < \frac{q_i^{\max}}{1 - q_i^{\max}}$ file legal or not at all. Then if there is hardly anyone, for whom $\pi_v^+ - \pi_c^+ \geq \frac{q_i^{\max}}{1 - q_i^{\max}}$ then administrators have no incentive to investigate (again unless their direct incentives are strong enough to induce them to investigate even if they know that all applicants plan legally.

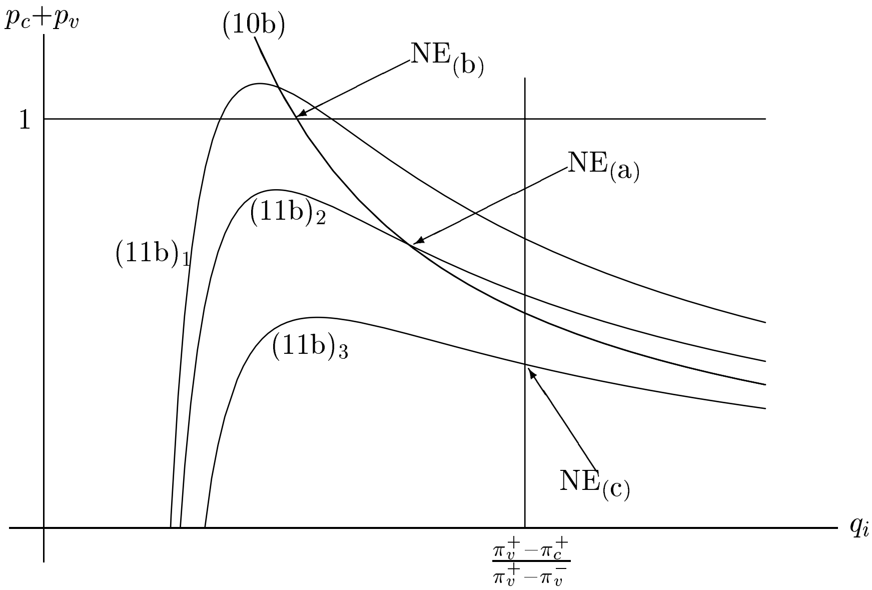


Figure 3: Nash equilibria of the extended inspection game in the $(q_i, p_c + p_v)$–space

p_c/p_v and q_g/g_i very quickly approach their equilibrium values.[9] In discussing the effects of policy changes on the location of the Nash equilibria, I will therefore concentrate on those intersections in which (10b) intersects (11b) from above as in the figure.

Case (b) is defined by the intersection of the equality (10b) with $p_c + p_v = 1$ when the $p_c + p_v$–value of the function (11b) is larger than 1. Finally, case (c) is defined by the intersection of the function defined by equality (11b) and $q_i = \frac{\pi_v^+-\pi_c^+}{\pi_v^+-\pi_v^-}$ which implies $\bar{q}_g = \frac{\pi_c^+-\pi_v^-}{\pi_v^+-\pi_v^-}$ when the resulting marginal disutility of effort $\tilde{e}u'((p_c + p_v)q_i\tilde{e})$ is less than $\frac{\Delta_c\Delta_v}{\Delta_c+\Delta_v}$. The fourth case ($p_a = 0$ and $q_d = 0$ with both functions (10b) and (11b) being above the intersection of $p_c + p_v = 1$ and $q_i = \frac{\pi_v^+-\pi_c^+}{\pi_v^+-\pi_v^-}$) is not included in the graph, but is easy to analyze.

The function defined by (10b) as equality is strictly positive and decreasing: $(p_c+p_v)q_i$ must be constant. The slope of the graph of the function defined by (11b) as equality is given by

$$\frac{\mathrm{d}(p_c + p_v)}{\mathrm{d}q_i} = \frac{-c\,\frac{\partial w}{\partial q_i} + \frac{(\pi_v^+-\pi_v^-)(\pi_c^+-\pi_c^-)}{\pi_v^+-\pi_c^++\pi_c^--\pi_v^-} - c\tilde{e}}{c\,\frac{\partial w}{\partial(p_c+p_v)}} \tag{12}$$

Any extreme of the function must be a maximum: Suppose that the numerator of the derivative is zero. Then changing q_i slightly does not affect p_c+p_v. Increasing (decreasing) q_i results in a proportional increase (decrease) of $(p_c + p_v)q_i$. Due to the hyperbolic shape of $w(\cdot)$ the term $\frac{\partial w}{\partial q_i}$ thus increases (decreases) which makes the numerator of the above derivative negative (positive). The extreme is thus a maximum. The maximum need

[9] Proof available from the author upon request.

not occur in the interval $q_i \in \left(0, \frac{\pi_v^+ - \pi_c^+}{\pi_v^+ - \pi_v^-}\right)$. If it does not, the function defined by (10b) as equality increases or decreases over the entire range. For the visualization of the arguments in figure 3 I assume that the maximum exists in the aforementioned range since that allows the discussion of both the increasing and the decreasing branch of the function. All arguments apply to the cases of a monotone function as well. The graphs of (11b) in figure 3 corresponding to the three cases differ in the level of c with lower c allowing for more applications at any given q_i.

5 Applications of the Model

5.1 Limits on the Duration of Procedures

In many German Länder, there are now sections in the procedural parts of the building codes restricting the duration of permission procedures for simple housing permits by an upper limit of between two weeks and three months — depending on the Land. The limit is enforced by a fictitious permit after the time limit has expired. Proponents of this policy argued that this would be a way to increase the number of applications without any need to interfere with the substance of the regulations. This policy would thus be a way to increase social welfare. I interpret these arguments as being based on the following assumptions.

Assumption 1 *The regulation is welfare enhancing. In other words, any permission granted to a project which complies with the regulation increases social welfare by* $w_c > 0$ *and any permission granted to a project which violates the regulation decreases social welfare by* $w_v > 0$.

Assumption 2 *If the number of applications increases and all other variables (including* p_c/p_v*) are constant, social welfare* W *increases. Formally:* $\frac{\partial W}{\partial(p_c+p_v)} > 0$

In the discussion of the welfare effects of the introduction of limits on the duration of the administrative licensing procedure and in the comparison with other policies, I assume that these assumptions are satisfied. I will show, that the limit on the duration of the procedure is nevertheless not necessarily welfare enhancing and that even if it is welfare enhancing, sanctions for filing an application which the administration will later reject perform even better.

The effects of the time limit on the licensing procedure are twofold. On the one hand, administrators are induced to be more flexible in adapting their working time to the highs and lows of the influx of applications. As an effect, waiting queues decline faster, the expected time an application has to wait until the administrator works on it becomes smaller — even if the average number of applications per time period and the proportion of applications an administrator investigates remains unchanged. In terms of figure 3 this means that the graph of function (11b) shifts upwards.

On the other hand, the investigation of applications becomes less attractive to administrators: increasing the proportion of cases investigated now not only results in more direct disutility of effort, but also increases the danger that another application remains too long in the queue and the fictitious permission replaces a decision which the administrator might want to have made. She will (partly) offset that danger by working more or more flexible. But this again results in additional disutility. For figure 3 this means that the graph of function (10b) shifts downwards.

If before and after the policy change administrators' incentives are strong enough to induce them not to deny permissions without investigation (case (c) in figure 3), the effect of the policy on the number of applications is unambiguously positive. However, the proportion of illegal plans among the applications will increase: due to both the increase in the number of applications and the shift of the function $u'(\cdot)$, the equilibrium value of $u'((p_c + p_v)q_i\tilde{e})$ will increase and so will $\frac{p_v \Delta_v}{p_c+p_v}$ due to the (first) equation in (10b). One cannot even exclude that this effect is so strong that the number of applications on legal plans declines in absolute terms. If this is the case, for example because the policy affects the administrators' incentives (expressed by $u'(\cdot)$) very strongly and hardly influences the waiting queues directly (admittedly an unlikely constellation), then the decline in p_c may be so large that the total number of permissions *granted* declines: since the equilibrium values of q_i and q_g remain unchanged, the number of permissions granted to legal plans $(q_g + q_i)p_c$ may decline more than the number of permissions granted to illegal plans $q_g p_v$ grows. But even in the less extreme case in which p_c grows as well, the increase in the proportion of illegal plans among the applications translates directly into an increase in the illegal plans all permissions granted. Then the welfare effect of the policy becomes ambiguous despite the unambiguous increase in the number of applications.

Similar effects result if the relevant Nash equilibrium is (or becomes) of case (a) and is on (or moves to) the decreasing branch of the function defined by equality (11b). Both the upward shift of (11b) and the downward shift of (10b) move the Nash equilibrium to the North-East i.e. the number of applications $p_c + p_v$ increases and the proportion of cases being investigated declines. Since in this case (10b) is satisfied as an equality, the ratio of illegal to legal plans among the applications $p_v/p_c = \Delta_c/\Delta_v$ is constant. Again allthough this effect looks positive on first sight, the effects on the numbers of permissions granted and the welfare effect are ambiguous. Would (10b) not or hardly shift, the effect on the number of permissions granted would be strictly positive: since under this assumption $(p_c + p_v)q_i$ is constant, the number of permissions granted to legal plans $(q_g + q_i)p_c = \frac{(p_c+p_v)\Delta_v}{\Delta_c+\Delta_v}\left(\frac{q_i\,(\pi_v^+ - \pi_v^-)}{\pi_v^+ - \pi_c^+ + \pi_c^- - \pi_v^-} + \frac{\pi_c^- - \pi_v^-}{\pi_v^+ - \pi_c^+ + \pi_c^- - \pi_v^-}\right)$ grows as $p_c + p_v$ increases. One can bring forward a similar argument for the number of permissions to illegal plans. However, if (10b) shifts downwards substantially, i.e. if the policy affects the incentives of the administrators strongly then the numbers of permissions granted may decline as an effect of the enforced limit on the duration of licensing procedures. Again, even if the numbers of permissions granted increase, the welfare effect is ambiguous since the proportion of permissions granted to illegal plans increases. Since $\frac{q_g}{q_g+q_i} = \frac{(\pi_c^+ - \pi_c^-)q_i + \pi_c^- - \pi_v^-}{(\pi_v^+ - \pi_v^-)q_i + \pi_c^- - \pi_v^-}$ declines in q_i and p_v/p_c is constant, the ratio $\frac{q_g p_v}{(q_g+q_i)p_c}$ increases as a consequence of the policy change.

If (10b) and (11b) intersect in the increasing branch of (11b), only the (negative) effect on the investigation of applications is unambiguous. The downward shift of (10b) may be stronger than the upward shift of (11b) which means that even the number of applications may decrease as a result of administration time limits. The intuition for this effect is the following: Administration time limits reduce the propensity of administrators to investigate applications. Thus the difference in permission probabilities for legal and illegal plans becomes smaller. Illegal plans become relatively more attractive. Therefore administrators more often deny permission without investigation which reduces the overall attractiveness of filing an application. In this case the welfare effect is unambiguously negative.

Finally, if the Nash equilibrium is of type (b), i.e. no citizen ever abstains from filing an application, — a case which the political discussion explicitly considers to be irrelevant — the welfare effect is negative: the number of applications remains constant (or decreases if the Nash equilibrium moves to the increasing branch of (11b)) and the administrative decisions become less sensitive to the legal merits of the single case (q_i declines) with the consequence that the proportion of illegal plans among the permissions granted increases.

The following proposition summarizes and pinpoints the effects of limits on the duration of administrative licensing procedures:

Proposition 2 *Suppose the extended inspection game appropriately describes the situation and a limit on the duration of administrative permission procedures is imposed or reinforced. Then the number of applications* may *increase consequentially.*

1. *If the number of applications does not increase, then the number of permissions granted and social welfare decrease.*

2. *If the number of applications increases, then the number of permissions granted* may *increase as a consequence of the new or stricter limit on the duration of the administrative procedure.*

   (a) *If the number of permissions granted does not increase, then social welfare decreases.*

   (b) *If the number of permissions increases then social welfare* may *increase.*

The proof of the proposition is in the appendix. There is an important insight with respect to the measurement of the success of the policy: it is *not* sufficient to only look at the number of applications filed or to the number of permissions granted if one wants to show that the policy is welfare improving. Conversely, if one observes that the number of applications does not increase as a consequence of the policy, not even the number of permissions granted will increase. And as long as the number of permissions granted does not increase as a consequence of the policy, then it is a clear failure with respect to social welfare.

Since the welfare effects of the policy enacted are at least ambiguous if not outright negative, the question for alternative proposes itself. In the following section I will discuss an approach which suggests itself to the economist: sanctions for citizens filing an application which is found to be illegal.

5.2 Deterrence of Illegal Plans

From an economist's point of view it would seem attractive to give incentives to applicants not to file for permissions with illegal plans. An easy way to do so would be to impose penalties on applicants whose plan the courts or the administration finds illegal. For simplicity of the argument, I restrict myself to the case that the fine is imposed according to the administrative decision, control by imperfect courts would not change the results qualitatively.

Obviously, with imperfect administrations and imperfect courts, such penalties do not only have the intended deterrence effect on illegal plans, but also unintended side effects on the incentives of administrators to investigate applications and, as a consequence of this, on the attractiveness of filing for permissions for legal plans. While the model presented here exaggerates the unintended side effects due to its remaining linearities, it pinpoints the problems of the deterrence approach.

To include deterrence in the model, I subtract a fine f from the expected payoff from being denied permission.[10] Formally, I replace π_c^- and π_v^- by $\pi_c^- - f$ and $\pi_v^- - f$, respectively. The first and the last condition in proposition 1 then become:

$$\bar{q}_g = \frac{(\pi_c^+ - \pi_c^- + f)q_i + \pi_c^- - \pi_v^-}{\pi_v^+ - \pi_c^+ + \pi_c^- - \pi_v^-} \leq \frac{\pi_c^+ - \pi_v^- + f}{\pi_v^+ - \pi_v^- + f} \tag{10a$'$}$$

and, respectively,

$$\begin{aligned} 0 \leq q_i \frac{(\pi_c^+ - \pi_c^- + f)(\pi_v^+ - \pi_v^- + f)}{\pi_v^+ - \pi_c^+ + \pi_c^- - \pi_v^-} + \frac{\pi_v^+(\pi_c^- - f) - \pi_c^+(\pi_v^- - f)}{\pi_v^+ - \pi_c^+ + \pi_c^- - \pi_v^-} \\ -k^o - c(q_i\tilde{e} + w(p_v + p_c, q_i\tilde{e}; \cdot)) \,. \end{aligned} \tag{11b$'$}$$

Conditions (10b) and (11a) remain unchanged. The qualitative form of (11b′) in the $(q_i, p_c + p_v)$–space also is unaffected.

From (10a′) one can see that compared to the number of applications investigated relatively more applications will be granted permission without investigation if the fine is larger. The intuition is the following. Because (10b) remains unchanged, the proportion of legal plans among the applications must stay the same. Hence in equilibrium the administrators must become more prone to grant permissions in order to offset the deterrence effect of the fine or applicants would cease to apply with legal plans and the game would be out of equilibrium. That the proportion of legal plans among the application must remain unchanged is of course an artefact of the linearity of administrators' expected utility in q_g and g_d. Relaxing this assumption slightly[11] would allow for a change in the proportion of legal plans and thus require only a lesser increase in the administrators' relative willingness to grant permission without investigation.

[10] If the fine may be repealed in the court procedure, a relatively smaller (expected) fine would be appropriate for the denial of permission to legal plans. With the possibility of court repeals the amount of the fine might also influence the probabilities of appeals and thus the administrators' expected sanctions for falsely denying permission. This extension is, however, beyond the scope of this paper.

[11] One could for example assume that applicants and third parties are more likely to challenge the administrative decision in court, if administrators deny or grant, respectively, more permissions without investigation. Then the administrators' expected punishments for handing down a wrong decision would increase in the respective probabilities of committing such an error: Δ_c would grow in q_d (i.e. one would have to write $\Delta_c(q_d)$ with $\Delta_c'(q_d) > 0$) and Δ_v would grow in q_g (i.e. $\Delta_v'(q_g) > 0$). Alternatively, one could drop the assumption that investigation of a case leads to perfect information and replace it by the more realistic assumption that investigative effort decreases both errors of type one (false permissions) and errors of type two (false denials of permission) and that the trade-off between the error types is convex.

In addition, (10a$'$) implies that the upper limit of q_i, which is given by $\frac{\pi_v^+ - \pi_c^+}{\pi_v^+ - \pi_v^- + f}$ decreases in the fine. Again the reason is the necessity to offset the deterrence effect in equilibrium: if the upper limit of q_i remained unchanged, the same would be true for the corresponding $\bar{q}_g = 1 - q_i$. Illegal plans would become completely deterred, the players' behavior could not be in (an interior) equilibrium.

The effect of the fine on the function defined by (11b$'$) is ambiguous: for small fines f and small investigation probabilities q_i, the value of $p_c + p_v$ defined by (11b$'$) as equality may decrease in the fine. For large fines or investigation probabilities close to the upper bound, the value of $p_c + p_v$ defined by (11b$'$) as equality will necessarily move up.

Thus, the effect of introducing or slightly increasing a small fine the on the number of applications may be negative with the effect on the investigation probability being positive. Since the proportion of legal plans among the applications remains constant the welfare effect is ambiguous: the loss of applications may be outweighed by a lower probability that legal plans are rejected. This effect, however, can only occur if not only the fine is and remains small, but also the administrators are rather reluctant to investigate in equilibrium. If this is not true, i.e. if the fine is or becomes sufficiently large or administrators rarely deny permission without investigation, the graph of the function defined by (11b$'$) as equality will move up in figure 3 in the relevant range. Consequently, the equilibrium number of applications will increase and the administrators' willingness to investigate will decrease. Since this is a complete reversal of the previous argument, the welfare effects remain ambiguous.

However even with this ambiguity of the welfare effects, one can show that the fine system improves social welfare more (or reduces it less) than the limit to the duration of the licensing procedure under rather weak conditions.

Proposition 3 *Suppose the extended inspection game appropriately describes the situation. Then by imposing sufficiently large fines on applicants whose plan the administration found illegal one can induce the same increase in the number of applications as by limiting the time which the concerned administrator has to hand down her decision after the application is filed. With the same increase in the number of applications, the fine induces a larger increase in welfare than the limit on the duration of the procedure unless (a) both policies to increase the number of applications decrease social welfare or (b) no permission is denied without investigation. If either of these two cases occurs the sign of the difference of the welfare effects of the two policies is ambiguous.*

The proposition (proof in the appendix) has an important implication for the merits of the policy of imposing limits on the duration the administrative procedure may take: Unless all legal plans are permitted, the policy either has negative welfare effects or is inferior to a system of fines for applications to which permission is denied. Hence if the fine system is a feasible alternative to increase the number of applications the fine should be introduced together with the time limit, and if the two alternatives happen to be mutually exclusive, a benevolent government should choose the fine system instead of the limit on the duration of the licensing procedure. Only if no applicant with a legal plan is denied permission (i.e. if no type one errors occur), the limitation of the duration of the process *may* be superior to the fine system.

Given this clear advantage of the fines system, one may ask why politicians are reluctant to rely more heavily on systems which imply fines. Reasons for this reluctance may have to be searched in variations of the model which take care of some lack of realism in the model. The next section will consider some of such variations.

6 Variations of the Model

Variations of the model leading towards assumptions which seem to be closer to reality might cast doubts on the rather clear results of the previous section with respect to the superiority of the fines system. One could see the first problem in the model of decision making by administrators. It is anything else but realistic. I will therefore discuss a more realistic model of administrative decision making (section 6.1). I will show that one can express this variation of the model in a very similar way as the model presented so far. Not surprisingly, the results change only under very specific conditions. Another drawback of the model may be seen in the completeness of the citizens' information on the legal merits of their plans. In a variation of the model (section 6.2), I will show that the introduction of a sufficient amount of incomplete information and risk aversion reverses the results of proposition 3. A brief discussion of remedies for the problems resulting from risk aversion will conclude this section.

6.1 Do Administrators Gamble?

In the model presented so far, administrators where presented as gamblers who deliberately choose between thoroughly investigating the cases brought before them and just flipping coins. As this is not only offensive to real world administrators but also fails to correspond to casual experience, I now briefly present an alternative model of administrators' decision making.

Assume that the general framework is the same as before, i.e. the administrator cannot influence the number of applications filed with him nor the proportions of applications based on legal and on illegal plans. Also, I continue to assume that the administrators learn about the average number and the average legal merits of the applications in a way which approaches the real number and average legal merits in the long run, if the they remain constant. As before, administrators thus have to know the expected number of applications filed with them and their average legal merits. Finally, administrators remain subject to (expected) sanctions for wrong decisions and investigative effort generates disutility at a rate increasing in the total investigative effort exerted.

I change, however, the assumptions on how investigative effort changes the information of the administrator on the single case. The new assumptions will be very general and may thus be much more intuitive. In particular, I assume that — other things being equal — additional investigative effort continuously reduces the administrator's probability of committing errors of type one (grant permission to a plan which violates the law) or of type two (deny permission to a plan complying with the law) or both error types, depending on how the additional effort is used. The administrator could, for example, use all additional effort to reduce the probability of committing errors of type one. Then the probability of errors of type two may remain unchanged, or slightly grow[12] or decline[13], but it will decline much less than if the administrator directed all additional effort on avoiding errors of type two. Equivalently, one could say that for any given level of investigative effort, there is a trade-off between avoidance of errors of type one and avoidance of errors of type two.

Denoting the respective error probabilities by q_g and q_d for type one and type two errors, respectively,[14] one can formalize the argument by expressing the probability to commit a type two error as a convex function $q_d(q_g, \bar{e})$ where $\bar{e}$ is the effort exerted per application and the first derivatives of the function have the following properties:

$$\frac{\partial q_d}{\partial q_g} < 0, \quad \frac{\partial q_d}{\partial \bar{e}} < 0, \quad \frac{\partial^2 q_d}{\partial q_g^2} \leq 0, \quad \frac{\partial^2 q_d}{\partial \bar{e}^2} \geq 0, \quad \frac{\partial^2 q_d}{\partial q_g \partial \bar{e}} \leq \frac{\partial^2 q_d}{\partial \bar{e}^2} \frac{\frac{\partial q_d}{\partial q_g}}{\frac{\partial q_d}{\partial \bar{e}}} \tag{13}$$

The assumption on the cross-derivative ensures symmetry: for fixed q_d, the type one error probability q_g decreases in $\bar{e}$ at a non-increasing rate (in absolute terms), the assumption thus corresponds to the non-negativity assumption on $\frac{\partial^2 q_d}{\partial \bar{e}^2}$. These (weak) convexity assumptions on the error probabilities as functions of the investigative effort reflect the idea that an optimizing administrator would level out all strict concavities by randomizing between to effort levels. At the same time, they allow me to assume that an administrator exerts the same level of effort on all applications filed with him. Due to the assumption of identical administrators, this also implies that in equilibrium all administrators exert the same investigative effort on all applications. With these assumptions, an administrator's expected utility is given by:

$$\mathrm{E}\tilde{U}(q_g, \bar{e}) = -u((p_c + p_v) \cdot \bar{e}) - p_c \Delta_c q_d(q_g, \bar{e}) - p_v \Delta_v q_g \tag{14}$$

If the trade-off between error probabilities is linear on a one-to-one basis ($\frac{\partial q_d}{\partial q_g} = -1$), the administrator's expected utility reduces to

$$\mathrm{E}\tilde{U}(q_g, \bar{e}) = -u((p_c + p_v) \cdot \bar{e}) - p_c \Delta_c (1 - q_i(\bar{e}) - q_g) - p_v \Delta_v q_g$$

where $1 - q_i(\bar{e})$ expresses the sum of the error probabilities which only depends on the effort exerted per application. If the sum of error probabilities is linear in the effort per application, one can write: $q_g + q_d = 1 - q_i(\bar{e}) = 1 - \eta\bar{e}$ where η may be interpreted as the error probability reduction per unit of effort. The administrator's expected utility then reduces to

$$\mathrm{E}\tilde{U}(q_g, \bar{e}) = -u((p_c + p_v) \cdot \bar{e}) - p_c \Delta_c (1 - \eta\bar{e} - q_g) - p_v \Delta_v q_g$$

or

$$\mathrm{E}U(q_i, q_g, q_d) = -u\left((p_c + p_v) \frac{q_i}{\eta}\right) - p_c \Delta_c q_d - p_v \Delta_v q_g$$

[12] This would be the case if efforts to produce correct evidence on illegal plans are likely to produce correct evidence on legal plans as well

[13] This would be the case if efforts to produce correct evidence on illegal plans are likely to produce false evidence against legal plans as well.

[14] Note that this is not an abuse of notation: these variables expressed exactly these error probabilities in the previous sections.

$$\text{subject to } q_i + q_g + q_d = 1$$

which is the same as equation (7) if one lets $\frac{1}{\eta} = \tilde{e}$. Formally, the model presented in section 4.2 is thus but a special case of one developed here. Note, however, that the assumptions leading to the same formal presentation differ: the model of section 4.2 was based on the assumption that the administrator selects some applications to investigate them which yields perfect knowledge of the legal merits and flips a (possibly loaded) coin on the other applications. Now the administrator investigates all applications to the same extent which yields incomplete information on all applications and grants (denies) permission if for example, her evidence that a plan is legal (illegal) is above some threshold level.[15] Given the formal identity of the two models, all results transfer to the current model, of course.

Now consider the case that only the trade-off between the two error probabilities is linear, but the sum of error probabilities is convex in the effort exerted on each application. Then effort to reduce information incompleteness exhibits decreasing returns to scale: $\frac{\partial^2 q_d}{\partial \bar{e}^2} > 0$ which results in $q_i'(\bar{e}) > 0$, $q_i''(\bar{e}) < 0$). One can then still write the administrator's expected utility as

$$\mathrm{E}U(q_i, q_g, q_d) = -u((p_c + p_v)e(q_i)) - p_c\Delta_c q_d - p_v \Delta_v q_g$$

$$\text{subject to } q_i + q_g + q_d = 1$$

where $e(q_i)$ is the reverse function of $q_i(\bar{e})$ i.e. $e(q_i(\bar{e})) = \bar{e}$ and thus has the properties $e(0) = 0$, $e'(q_i) > 0$, and $e''(q_i) > 0$. Among the equations determining the Nash equilibrium, this only affects (10b) which now becomes:

$$e'(q_i) \cdot u'((p_c + p_v)e(q_i)) = \frac{p_v \Delta_v}{p_c + p_v} \leq \frac{\Delta_c \Delta_v}{\Delta_c + \Delta_v} \tag{10b$'$}$$

Note that this is of course identical to (10b) if $e(q_i) = \tilde{e} q_i$. For the figure 3 the transition to the nonlinear case $e(q_i)$ means that the graph of equality (10b) becomes steeper.

While this change does not affect proposition 2, the results of proposition 3 are weakened: imposing upper limits on the duration of the licensing procedure may now be superior to the fines system from a welfare point of view, even if both are welfare increasing. This requires, however, that the policy of limits on the duration of procedures affects the function $u'(\cdot)$ only slightly or not at all.

The intuition behind this change of results is the following: in the original model, both policies did not increase the total number of applications which are investigated $((p_c + p_v)q_i)$: due to equality (10b), this number was constant under the fines system and would decrease as a consequence of the limit on the duration of licensing procedures (or remain constant if the latter policy did not affect the function $u'(\cdot)$). Thus all welfare gains could only be due to the additional permissions which were granted without investigation. As this number of additional permissions without investigation grows more with the fines system than with limits on the duration of licensing procedures, the former had to be superior at least if the latter had a positive effect on welfare.

[15] Other specifications are possible, depending on the exact model.

Now $(p_c + p_v)q_i$ cannot denote the total number of applications which are investigated any more since, this concept need not make any sense in the variation of the model. Rather, $(p_c + p_v)q_i$ now describes the number of applications which cannot suffer from a mistake independently of their legal merits. This number now grows if the function $u'(\cdot)$ is unaffected by a policy change which increases the number of aplications: due to the convexity of $e(q_i)$, the product $(p_c+p_v)q_i$ grows if p_c+p_v grows but $e'(q_i)u'((p_c+p_v)e(q_i))$ remains constant. This increase in the number of applications upon which administrators decide correctly independently of their legal merits constitutes a social gain and may offset a loss of social welfare due to an increased number of permissions granted without investigation. If this is the case for the policy of limits on the duration of licensing procedures, then a policy of fines which results in (approximately) the same increase (decrease) of the number of applications (of the investigation probability) will perform worse than the former policy, because it grants even more permissions without investigation. Obviously, this cannot occur if the limit on the duration of the licensing procedure increases the function $u'(\cdot)$ so much that $(p_c + p_v)q_i$ cannot grow under this policy.

Finally consider the case in which not only sum of error probabilities is convex in the effort exerted on each application but also the trade-off between the error probabilities. Without going into details[16] note that a reduction of q_i which goes along with an increase of the number of applications q_g decreases as well while q_d increases. Due to the convexity of q_d in q_g I conjecture that $-\frac{\partial q_d}{\partial q_g}$ increases when q_i decreases (at least for large q_g). Then the equilibrium value of p_v/p_c must also increase. The additional tendency to permit without investigation, which the fines system brings about as discussed in the previous paragraphs, becomes then more threatening to social welfare. It thus becomes more likely that the fines system increases social welfare less than a limit on the duration of the administrative procedure. This casts additional doubts on proposition 3.

With more complex and more realistic assumptions on the decision making of administrators, the fines system may increase social welfare less than the limit on the duration of licensing procedures. However, this can only happen, if the increases of the disutility of effort which the time limit induces directly is minor. If it is large, then the fines system will be superior.

6.2 Incompletely Informed Citizens

So far, I assumed that the citizens perfectly know whether their plan is legal or violates the law. There may be good reasons to challenge this assumption. The most simple way to replace it with incomplete information is to assume that citizens still perfectly know what plan they have but that the type of the plan correlates only imperfectly with the legal merits. In particular I assume that the citizens still have two alternative plans which they can pursue or not. Still the plan which is more likely to be legal (i.e. welfare enhancing, see the discussion above) gives the lower payoff if permission is granted ($\pi_c^+ < \pi_v^+$) but the higher or equal payoff if permission is denied ($\pi_c^- > \pi_v^-$). However now the probabilities that the alternative plans are legal are not one and zero any more but rather τ_c and τ_v where $\tau_c \in (0,1)$ and $\tau_v \in (0, \tau_c)$. When administrators investigate a case, they find out

[16] This part is still subject to further research.

whether the underlying plan is legal or not, but do not care about the payoffs of the plan.

The expected payoffs with fines of a citizen filing an application based on a plan with the higher probability of being legal (call it a "c-plan") thus is

$$\mathrm{E}V_c = (\bar{q}_g + \bar{q}_i\tau_c)\pi_c^+ + (1 - \bar{q}_g - \bar{q}_i\tau_c)(\pi_c^- - f) - k^o - c(q_i\tilde{e}+w(p_v+p_c, q_i\tilde{e}; \cdot)) \tag{15}$$

where the fine f may be zero or positive, and the expected payoffs with fines of a citizen filing an application based on a plan with the lower probability of being legal (call it a "v-plan") is

$$\mathrm{E}V_v = (\bar{q}_g + \bar{q}_i\tau_v)\pi_v^+ + (1 - \bar{q}_g - \bar{q}_i\tau_v)(\pi_v^- - f) - k^o - c(q_i\tilde{e}+w(p_v+p_c, q_i\tilde{e}; \cdot)) \tag{16}$$

With these alterations to expected payoffs, the among equations defining the Nash equilibrium again are (10a) and (11b). They now become

$$\begin{aligned} \bar{q}_g &= \frac{(\tau_c(\pi_c^+ - \pi_c^- + f) - \tau_v(\pi_v^+ - \pi_v^- + f))q_i + \pi_c^- - \pi_v^-}{\pi_v^+ - \pi_c^+ + \pi_c^- - \pi_v^-} \\ &\leq \frac{\tau_c\pi_c^+ - \tau_v\pi_v^+ + (1-\tau_c)(\pi_c^- - f) - (1-\tau_v)(\pi_v^- - f)}{\pi_v^+ - \pi_v^- + f} \end{aligned} \tag{10a$''$}$$

and, respectively,

$$\begin{aligned} 0 \leq q_i &\frac{(\pi_c^+ - \pi_c^- + f)(\pi_v^+ - \pi_v^- + f)(\tau_c - \tau_v)}{\pi_v^+ - \pi_c^+ + \pi_c^- - \pi_v^-} + \frac{\pi_v^+(\pi_c^- - f) - \pi_c^+(\pi_v^- - f)}{\pi_v^+ - \pi_c^+ + \pi_c^- - \pi_v^-} \\ &-k^o - c(q_i\tilde{e}+w(p_v+p_c, q_i\tilde{e}; \cdot)) \,. \end{aligned} \tag{11b$''$}$$

These changes in the equilibrium conditions alter the basic result of proposition 3:

Proposition 4 *Suppose the extended inspection game appropriately describes the situation. Then fines cannot be large enough to increase the number of applications if the correlation between the type of the plans and their legal merits is too small. With sufficiently small correlation between the type of the plans and their legal merits, introducing fines decreases social welfare even if one can increase social welfare by increasing the number of applications via a limit on the time which the concerned administrator may use to hand down her decision after the application is filed.*

The intuition behind this proposition is the following. Suppose that the correlation between the type of the plans and their legal merits is very small. Then a fine can hardly influence the citizens' choice between the two plans: whether they are fined or not hardly depends on this choice. However they can avoid the threat of the fine by abstaining from filing an application, be it based on a c-plan or on a v-plan. Thus the larger the fine, the smaller the application costs must be in order to induce citizens to file an application.

One could cure this problem by redistributing the collected fines as rewards among the applicants to whom permission was granted. Then even in the most extreme case of lacking correlation between the type of the plans and their legal merits ($\tau_c = \tau_v$), this fine-and-reward system would have no deterrence effect on filing an application. And if the correlation is positive ($\tau_c > \tau_v$), then a fine which is completely redistributed gives incentives to choose a c-plan without lowering the average payoffs of filing an application. Formally, the second term in (11b$''$) so that the effect of the fine on the right hand side of (11b$''$) is positive and thus allows for more applications. Hence, if the fine is completely redistributed among the successful applicants, then the superiority of the fines system as developed in 3 is true *a fortiori*.

The problem that the threat of a fine induces abstention can only be an argument against fines if the fine cannot be fully redistributed among the successful candidates. This may be the case if redistribution consumes resources or if citizens are sufficiently risk avers. In the latter case it may be possible to redistribute the fines themselves but the effect on expected utility differs: larger fines mean disproportionately larger losses in expected utility than larger rewards for granted permissions increase expected utility. The effect is then comparable to the basic insight of the formal principal-agent-theory (Tirole et al (XXX): while the fines and rewards increase the incentives to apply with legal instead of illegal plans, one has to take into account the participation constraint: the fines and rewards reduce the expected utility of the citizen in equilibrium which will more and more citizens drive into abstention, i.e. non-participation. Proposition 5 extends proposition 4 according to these arguments:

Proposition 5 *Proposition 4 remains true when fines are redistributed to successful applicants if:*

1. *not all collected fines are redistributed to the successful applicants or*
2. *all collected fines are redistributed but citizens are risk averse*

7 Conclusion

In this paper, I have developed a model to describe how the (legal) quality and the quantity of citizens' applications for public law permissions (licenses) interact with the incentives of administrators to investigate single applications or to rely in one way or other on their prior information. Based on the model I showed that limits on the time which administrations may use to hand down a decision as they are enforced in German administrative law, may not only fail to increase social welfare, but may also fail to have a positive effect on the number of permissions granted and may even reduce the number of applications.

As an alternative approach I discussed fines imposed on applicants to whom permission is denied. In the basic model, these fines improve social welfare more than limits on the duration of administrative procedures, whenever the latter system has a positive effect on social welfare. The consequence based on this model would be that either one should not try to increase the number of applications by limiting the time administrators may take to hand down a decision, or one should at least supplement, if not replace the time limit system by fines on rejected applications.

This result was shown to be weaker if investigation technologies are convex: then the result is true only when the direct effect of the time limit system on the administrators' marginal disutility of effort is strong enough to outweigh the effect that with convex technologies effort becomes more profitable if distributed among more cases. I also showed that the result may fail to be true if citizens are incompletely informed about the legal merits of their own plans. When citizens are sufficiently risk averse, even a redistribution of the collected fines among the successful applicants would not solve the problem.

I did not discuss a third argument which might deteriorate the effects of fines: increased incentives for corruption. I did not discuss it in this paper, because this would require substantial extensions of the model. In such an extensions one could argue along the following lines. Higher deterrence of illegal plans includes a higher risk even for those applicants who have legal plans. This makes corruption more attractive: the difference between getting and not getting the permission is not only the value of the permission but also the fine, in addition. Thus, penal law becomes less effective in deterring corruption. This may only be a minor problem for the single case, but much of the problems of corruption result from the fact that once an official has been corrupt in one decision, she becomes far more likely to become corrupt in further decisions as well, because the additional punishment she has to face becomes smaller with every event of corruption (cf. von Wangenheim (1998)).

In administrative practice, we rarely find rewards systems, perhaps because of the aforementioned danger of corruption. However fine systems do exist, sometimes in a very open form where additional administrative fees become due for frivolous applications, i.e. applications for permissions which would clearly be illegal. While a differentiation between clearly and unclearly illegal plans would require an extension of the model presented in this paper to include at least four alternative actions of the citizens the basic idea remains the same: the fee deters some applications which should not get permission and thus allows a more thorough differentiation between legal and illegal plans. The reason why this deterrence is restricted to the "clearly" illegal plans may be the effect of imperfect information described in section 6.2: deterrence may extend too much to the plans which improve social welfare.

A more indirect approach to impose fines (again without rewards) on plans failing in the administrative procedure (where imposition and enforcement of the fine usually is controlled by the courts) is the following innovation in German building codes: applicants for a building permit for a small[17] residential house may start the construction after filing the application unless the administration vetoes within ten or fourteen[18] days. However, this right does not include or simulate a full scale permit. The risk of not meeting the legal standards and therefore having to remodel or destruct the building goes with the applicant.[19]

The rule is not exactly a fines system, since the applicant does not have to start construction. Starting construction might work as a signal of trust that one's own plan complies with the regulations. However, a separating equilibrium does not seem to exist: Both types of applications must occur both n the set of applicants who immediately start construction and in the set of the applicants who wait for the formal permission.

[17]The definitions of "small" vary substantially between the German Länder: in some it includes buildings of a height of up to ten meters and including several apartments.

[18]Numbers again vary between the Länder.

[19]I am not yet aware whether this is actually a risk or whether administrators get trapped in weighing the remodeling or deconstruction costs against the marginal gain from changing to the legal form of building.

Otherwise, the set the applicants where only one type occurs would be empty due to lemma 1 which extends immediately to a signaling version of the model. However a formal model of this policy approach is still up to further research.

Appendix

A Proof of Lemma 1

A proof of the first two parts by contradiction is simple: first, suppose a Nash equilibrium with $p_c^* > p_v^* = 0$ existed. Then condition (9) implies $q_g = 1$ for all administrators by $\mathrm{E}U_g = 0 > \max(\mathrm{E}U_i, \mathrm{E}U_d)$. This implies $\mathrm{E}V_v > \mathrm{E}V_c$ and thus $p_c^* = 0$ by condition (8) which contradicts the supposition. Second, suppose a Nash equilibrium with $p_v^* > p_c^* = 0$ existed. Then condition (9) implies $q_d = 1$ for all administrators by $\mathrm{E}U_d = 0 > \max(\mathrm{E}U_i, \mathrm{E}U_g)$ and thus $\bar{q}_i = \bar{q}_g = 0$. This implies $\mathrm{E}V_c > \mathrm{E}V_v$ and thus $p_v^* = 0$ by condition (8) which contradicts the supposition.

For the third part suppose a Nash equilibrium with $p_v^* + p_c^* > 0$ and $q_g = 0$ or $q_g = 1$ for all administrators existed. Then $p_c > 0$ and $p_v > 0$ by the first two parts of the lemma. Then condition (8) implies $\mathrm{E}V_v = \mathrm{E}V_c$ and thus $\bar{q}_g \in (0, 1)$ which contradicts the supposition. For the fourth part suppose a Nash equilibrium with $p_v^* + p_c^* > 0$ and $q_i = 0$ for all administrators existed. Then $q_d = 1 - q_i - q_g > 0$ at least for some administrators due to the third part. Again, $p_c > 0$ and $p_v > 0$ hold by the first two parts of the lemma. Thus condition (9) implies $\tilde{e}u'(0) \geq \frac{p_c \Delta_c}{p_c + p_v} = \frac{p_v \Delta_v}{p_c + p_v}$. But then $\tilde{e}u'(0) \geq \frac{\Delta_c \Delta_v}{\Delta_c + \Delta_v}$ which contradicts the assumptions on $u(\cdot)$.

For the last part note that with $p_c^* = p_v^* = 0$, $\mathrm{E}U(q_i, q_g, q_d) \equiv 0$, i.e. all actions yield the same payoff: $\mathrm{E}U_i = \mathrm{E}U_g = \mathrm{E}U_d = 0$ and thus condition (9) is satisfied. The other two conditions ensure that $\mathrm{E}V_c^* \leq 0$ and $\mathrm{E}V_v^* \leq 0$ so that the applicants have no incentive to deviate for the equilibrium behavior (condition (8) is satisfied). Note that $\bar{q}_g^* \leq \max\left(\frac{\bar{q}_i^* c\tilde{e} + k^o - \pi_v^-}{\pi_v^+ - \pi_v^-}, \frac{\bar{q}_i^*(c\tilde{e} - \pi_c^+ + \pi_c^-) + k^o - \pi_c^-}{\pi_c^+ - \pi_c^-}\right)$ cannot be satisfied if $k^o < \min(\pi_c^-, \pi_c^+ - c\tilde{e})$: even with $q_g = 0$, the term $\mathrm{E}V_c$ is strictly positive for all q_i when $p_c + p_v = 0$, i.e. when $-c(q_i\tilde{e} + w(p_v + p_c, q_i\tilde{e}; \cdot)) = c\, q_i\, \tilde{e}$. □

B Proof of Proposition 1

To prove the proposition I proceed in five steps. I first show that in each Nash equilibrium the first equalities in (10a) and (10b) must be satisfied. I then show that in each Nash equilibrium the strict inequalities in (10a) and (10b) are mutually exclusive. In the third step I show the same for (11a) and (11b). In step four I show that if any quadruple (p_c, p_v, q_i, q_g) with $p_v + p_c > 0$ satisfies both conditions then it is a Nash equilibrium. Finally I show the existence of at least one Nash equilibrium with $p_c + p_v > 0$.

Step 1 (equalities in (10)): By assumption, the number of applications is strictly positive. Thus by lemma 1, $p_c > 0$ and $p_v > 0$. Then in a Nash equilibrium, $\mathrm{E}V_c = \mathrm{E}V_v$ by condition (8) which is equivalent to the first equality in (10a). Further, the assumption of a strictly positive number of applications implies $q_g > 0$ and $q_i > 0$ due to lemma 1. Then the first equation in (10b) is a direct consequence of (9).

Step 2 (mutual exclusion of strict inequalities in (10)): If inequality in (10a) is strict, then $q_d = 1 - q_i - q_g > 0$. Thus (9) implies $p_c\Delta_c = p_v\Delta_v$ which results in $\frac{p_v\Delta_v}{p_c+p_v} = \frac{\Delta_c\Delta_v}{\Delta_c+\Delta_v}$. Hence there must not be a strict inequality in (10b). Now assume that there is a strict inequality in (10b). Then $\frac{p_v\Delta_v}{p_c+p_v} < \frac{\Delta_c\Delta_v}{\Delta_c+\Delta_v}$ implies $p_c\Delta_c > p_v\Delta_v$. By condition (9) this yields $q_d = 0$ or $q_g + q_i = 1$ which excludes the strict inequality in (10a).

Step 3 (mutual exclusion of strict inequalities in (11)): If (11a) is a strict inequality, then $q_d > 0$. Hence condition (8) implies $\mathrm{E}V_c = \mathrm{E}V_v = \mathrm{E}V_a = 0$ which yields the equality in (11b). If (11b) is a strict inequality, then (8) implies $p_a = 0$ hence (11a) is an equality.

Step 4 (sufficiency of conditions): If any quadruple (p_c, p_v, q_i, q_g) satisfies (10b) and (11b) in the form of equalities and (10a) and (11a) in the form of weak inequalities, then $\mathrm{E}V_c = \mathrm{E}V_v = \mathrm{E}V_a$ and $\mathrm{E}U_i = \mathrm{E}U_g = \mathrm{E}U_d$ and thus all equilibrium conditions (8) and (9) are satisfied. Note that this still allows for $q_d = 0$ or $p_a = 0$ or even both. If the quadruple satisfies (10b) in the form of a strict inequality, then (10a) must be satisfied as an equality and thus $q_d = 0$. Since the strict inequality in (10b) implies $\mathrm{E}U_d = -p_c\Delta_c < \mathrm{E}U_g = -p_v\Delta_v$ and $\mathrm{E}U_d = -p_c\Delta_c < \mathrm{E}U_i = -(p_c + p_v)\tilde{e}u'((p_c + p_v)q_i\tilde{e})$ this is still consistent with (9). Similarly, if the quadruple satisfies (11b) in the form of a strict inequality, then $p_a = 0$ which, together with $\mathrm{E}V_c = \mathrm{E}V_v > \mathrm{E}V_a = 0$, is again consistent with (8).

Step 5 (existence of Nash equilibrium): Equations (10b) and (11b) define (implicit) functions $p_c + p_v \equiv p(q_i)$ if they are equalities. In particular (10b) as equality defines $p(q_i) = \frac{1}{q_i} u'^{(-1)} \left(\frac{\Delta_c\Delta_v}{(\Delta_c+\Delta_v)\tilde{e}}\right)$ where $u'^{(-1)}(\cdot)$ is the reverse function of $u'(\cdot)$. For small q_i, the value of $p(q_i)$ thus defined is larger than the value of p_c+p_v satisfying (11b) as equality for the same small values of q_i. For larger values of q_i there may be an intersection of the two functions. If there is, this defines a Nash equilibrium. If there is no intersection for values of $q_i \leq \frac{\pi_v^+ - \pi_c^+}{\pi_v^+ - \pi_v^-}$ then at $q_i = \frac{\pi_v^+ - \pi_c^+}{\pi_v^+ - \pi_v^-}$ (10a) is satisfied as equality. This allows (10a) to be a strict inequality which it is at the intersection of (11b) as equality with $q_i = \frac{\pi_v^+ - \pi_c^+}{\pi_v^+ - \pi_v^-}$. This intersection thus defines a Nash equilibrium. Due to $k^o < \pi_c^+ - \frac{\pi_v^+ - \pi_c^+}{\pi_v^+ - \pi_v^-} - c\tilde{e}$ the number of applications at this intersection is strictly positive. □

C Proof of Proposition 2

For the proof define $W = (q_g+q_i)p_c w_c - q_g p_v w_v$ as the overall effect of the regulated activity on social welfare and $M = (q_g + q_i)p_c + q_g p_v$ as the total number of permissions granted. With a slight abuse of notation, let $\frac{\partial q_i}{\partial(p_c+p_v)}$ denote the ratio of the effects of the time limit policy on the administrators' equilibrium willingness to investigate and on the the number of applications filed. Measuring the policy by its effect on the number of applications, one can formalize the effect of the policy on M and W by the total derivatives $\frac{\mathrm{d}M}{\mathrm{d}(p_c+p_v)}$ and $\frac{\mathrm{d}W}{\mathrm{d}(p_c+p_v)}$, respectively, both multiplied by the effect which the policy has on the number of applications. To improve readability, I will abbreviate as follows: $\pi_v \equiv \pi_v^+ - \pi_v^-$ and $\pi_c \equiv \pi_c^+ - \pi_c^-$.

As has been shown in the text, the number of applications filed may decrease as a consequence of the time limit policy, if the intersection of (10b) and (11b) which defines the (relevant) Nash equilibrium is in the increasing branch of (11b). If this is the case, then $\frac{\partial q_i}{p_c+p_v} > 0$, i.e. with the policy both the number of applications and the administrators' willingness to investigate decrease.

C.1 Part 1. of the Proposition

Since the negative effect of the policy on the number of applications can only occur if the Nash equilibrium is of type (a), one can write the effect of the policy on the number of permissions granted as

$$
\begin{aligned}
\frac{\mathrm{d}M}{\mathrm{d}(p_c+p_v)} &= \frac{\mathrm{d}((q_g+q_i)p_c+q_g p_v)}{\mathrm{d}(p_c+p_v)} \\
&= \frac{\mathrm{d}\left((p_c+p_v)\frac{(\pi_v q_i+\pi_c^- - \pi_v^-)\Delta_v+(\pi_c q_i+\pi_c^- - \pi_v^-)\Delta_c}{(\Delta_c+\Delta_v)(\pi_v-\pi_c)}\right)}{\mathrm{d}(p_c+p_v)} \\
&= \frac{\partial\left((p_c+p_v)\frac{(\pi_v q_i+\pi_c^- - \pi_v^-)\Delta_v+(\pi_c q_i+\pi_c^- - \pi_v^-)\Delta_c}{(\Delta_c+\Delta_v)(\pi_v-\pi_c)}\right)}{\partial(p_c+p_v)} \\
&\quad + \frac{\partial\left((p_c+p_v)\frac{(\pi_v q_i+\pi_c^- - \pi_v^-)\Delta_v+(\pi_c q_i+\pi_c^- - \pi_v^-)\Delta_c}{(\Delta_c+\Delta_v)(\pi_v-\pi_c)}\right)}{\partial q_i}\frac{\partial q_i}{\partial(p_c+p_v)} \\
&= \frac{(\pi_v q_i+\pi_c^- - \pi_v^-)\Delta_v+(\pi_c q_i+\pi_c^- - \pi_v^-)\Delta_c}{(\Delta_c+\Delta_v)(\pi_v-\pi_v)} \\
&\quad + (p_c+p_v)\frac{\pi_v\Delta_v+\pi_c\Delta_c}{(\Delta_c+\Delta_v)(\pi_v-\pi_c)}\frac{\partial q_i}{\partial(p_c+p_v)}
\end{aligned}
$$

which is strictly positive. Thus, as the time limit policy reduces the number of applications, the number of permissions granted decreases as well.

Now look at the effect on social welfare:

$$
\begin{aligned}
\frac{\mathrm{d}W}{\mathrm{d}(p_c+p_v)} &= \frac{\mathrm{d}((q_g+q_i)p_c w_c - q_g p_v w_v)}{\mathrm{d}(p_c+p_v)} \\
&= \frac{\mathrm{d}\left((p_c+p_v)\frac{(\pi_v q_i+\pi_c^- - \pi_v^-)\Delta_v w_c-(\pi_c q_i+\pi_c^- - \pi_v^-)\Delta_c w_v}{(\Delta_c+\Delta_v)(\pi_v-\pi_c)}\right)}{\mathrm{d}(p_c+p_v)} \\
&= \frac{\partial\left((p_c+p_v)\frac{(\pi_v q_i+\pi_c^- - \pi_v^-)\Delta_v w_c-(\pi_c q_i+\pi_c^- - \pi_v^-)\Delta_c w_v}{(\Delta_c+\Delta_v)(\pi_v-\pi_c)}\right)}{\partial(p_c+p_v)} \\
&\quad + \frac{\partial\left((p_c+p_v)\frac{(\pi_v q_i+\pi_c^- - \pi_v^-)\Delta_v w_c-(\pi_c q_i+\pi_c^- - \pi_v^-)\Delta_c w_v}{(\Delta_c+\Delta_v)(\pi_v-\pi_c)}\right)}{\partial q_i}\frac{\partial q_i}{\partial(p_c+p_v)} \\
&= \frac{(\pi_v q_i+\pi_c^- - \pi_v^-)\Delta_v w_c-(\pi_c q_i+\pi_c^- - \pi_v^-)\Delta_c w_v}{(\Delta_c+\Delta_v)(\pi_v-\pi_c)} \qquad (17) \\
&\quad + (p_c+p_v)\frac{\pi_v\Delta_v w_c-\pi_c\Delta_c w_v}{(\Delta_c+\Delta_v)(\pi_v-\pi_c)}\frac{\partial q_i}{\partial(p_c+p_v)} \qquad (18)
\end{aligned}
$$

The term in line (17) is positive due to assumption 2 ($\frac{\partial W}{\partial(p_c+p_v)} > 0$). This assumption also implies that the first factor of line (18) is positive as well:

$$0 < (\pi_v q_i+\pi_c^- - \pi_v^-)\Delta_v w_c - (\pi_c q_i+\pi_c^- - \pi_v^-)\Delta_c w_v$$

$$\begin{aligned}
&= \frac{(\pi_v q_i + \pi_c^- - \pi_v^-)}{\pi_v}\left(\Delta_v w_c \pi_v - \Delta_c w_v \frac{\pi_v(\pi_c q_i + \pi_c^- - \pi_v^-)}{\pi_v q_i + \pi_c^- - \pi_v^-}\right)\\
&= \frac{(\pi_v q_i + \pi_c^- - \pi_v^-)}{\pi_v}\left(\Delta_v w_c \pi_v - \Delta_c w_v \frac{\pi_c\left(\pi_v q_i + \frac{\pi_v}{\pi_c}(\pi_c^- - \pi_v^-)\right)}{\pi_v q_i + \pi_c^- - \pi_v^-}\right)\\
&< \frac{(\pi_v q_i + \pi_c^- - \pi_v^-)}{\pi_v}\left(\Delta_v w_c \pi_v - \Delta_c w_v \frac{\pi_c\left(\pi_v q_i + (\pi_c^- - \pi_v^-)\right)}{\pi_v q_i + \pi_c^- - \pi_v^-}\right)\\
&= \frac{(\pi_v q_i + \pi_c^- - \pi_v^-)}{\pi_v}(\pi_v \Delta_v w_c - \pi_c \Delta_c w_v)
\end{aligned}$$

As the second factor of line (18) is also positive, $\frac{\mathrm{d}W}{\mathrm{d}(p_c+p_v)} > 0$ which implies that social welfare decreases as a result of the new policy which reduces the number of applications.

The proof for the case that the number of applications is unaffected by the policy is similar: the term $\frac{\partial W}{\partial(p_c+p_v)}$ becomes irrelevant since $p_c + p_v$ remains constant. Only q_i decreases as result of the policy so that the effect of the policy on social welfare has the opposite sign of $\frac{\partial W}{\partial q_i}$ which is the first factor of line (17) and thus positive. Hence social welfare decreases as a consequence of the policy which keeps the number of applications unaffected.

C.2 Part 2. of the Proposition

The number of applications may increase if the Nash equilibrium is of type (a) and must increase if the Nash equilibrium is of type (c). First consider case (a) with an increasing number of applications as a consequence of the policy. The reaction of the number of granted permissions to the policy is determined by:

$$\begin{aligned}
\frac{\mathrm{d}M}{\mathrm{d}(p_c+p_v)} &= \frac{\mathrm{d}((q_g+q_i)p_c + q_g p_v)}{\mathrm{d}(p_c+p_v)}\\
&= \frac{(\pi_v q_i + \pi_c^- - \pi_v^-)\Delta_v + (\pi_c q_i + \pi_c^- - \pi_v^-)\Delta_c}{(\Delta_c+\Delta_v)(\pi_v - \pi_v)} && (19)\\
&\quad +(p_c+p_v)\frac{\pi_v\Delta_v + \pi_c\Delta_c}{(\Delta_c+\Delta_v)(\pi_v-\pi_c)}\frac{\partial q_i}{\partial(p_c+p_v)} && (20)\\
&\leq \frac{(\pi_v q_i + \pi_c^- - \pi_v^-)\Delta_v + (\pi_c q_i + \pi_c^- - \pi_v^-)\Delta_c}{(\Delta_c+\Delta_v)(\pi_v - \pi_v)} && (21)\\
&\quad -(p_c+p_v)\frac{\pi_v\Delta_v + \pi_c\Delta_c}{(\Delta_c+\Delta_v)(\pi_v-\pi_c)}\frac{q_i}{p_c+p_v}\\
&= \frac{\pi_c^- - \pi_v^-}{\pi_v - \pi_c} && (22)
\end{aligned}$$

The inequality in line (21) is strict unless the policy does not affect the function $u'(\cdot)$ for the following reason. Suppose the policy does not affect the function $u'(\cdot)$. Then the product $(p_c + p_v)q_i$ must remain constant. Hence $\frac{\partial q_i}{\partial(p_c+p_v)} = -\frac{q_i}{p_c+p_v}$ which yields the equality in line (21). If the policy affects the function $u'(\cdot)$ as argued in the text, then q_i becomes smaller than predicted by $\frac{\partial q_i}{\partial(p_c+p_v)} = -\frac{q_i}{p_c+p_v}$ as a result of the policy. Hence $\frac{\partial q_i}{\partial(p_c+p_v)} < -\frac{q_i}{p_c+p_v}$ which is the strict inequality in line (21).

Note that the term in line (22) is positive. Thus the effect of the policy on M is positive, if the function $u'(\cdot)$ hardly changes as a result of the policy. The effect on M is negative, however, if the function $u'(\cdot)$ becomes substantially larger as a consequence of the policy. In particular, the effect of the policy on M is negative if and only if the expression in lines (19) and (20) is negative, i.e. if and only if

$$\frac{\partial q_i}{\partial(p_c+p_v)} < -\frac{(\pi_v q_i + \pi_c^- - \pi_v^-)\Delta_v + (\pi_c q_i + \pi_c^- - \pi_v^-)\Delta_c}{(p_c+p_v)(\pi_v\Delta_v + \pi_c\Delta_c)} \tag{23}$$

If this is the case, then social welfare also decreases as a result of the policy:

$$\begin{aligned}
\frac{\mathrm{d}W}{\mathrm{d}(p_c+p_v)} &= \frac{\mathrm{d}\left((p_c+p_v)\frac{(\pi_v q_i+\pi_c^- -\pi_v^-)\Delta_v w_c-(\pi_c q_i+\pi_c^- -\pi_v^-)\Delta_c w_v}{(\Delta_c+\Delta_v)(\pi_v-\pi_c)}\right)}{\mathrm{d}(p_c+p_v)} \\
&= \frac{(\pi_v q_i + \pi_c^- - \pi_v^-)\Delta_v w_c - (\pi_c q_i + \pi_c^- - \pi_v^-)\Delta_c w_v}{(\Delta_c+\Delta_v)(\pi_v-\pi_c)} \qquad (24)\\
&\quad +(p_c+p_v)\frac{\pi_v\Delta_v w_c - \pi_c\Delta_c w_v}{(\Delta_c+\Delta_v)(\pi_v-\pi_c)}\frac{\partial q_i}{\partial(p_c+p_v)} \qquad (25)\\
&< \frac{((\pi_v q_i + \pi_c^- - \pi_v^-)\Delta_v w_c - (\pi_c q_i + \pi_c^- - \pi_v^-)\Delta_c w_v)(\pi_v\Delta_v + \pi_c\Delta_c)}{(\Delta_c+\Delta_v)(\pi_v-\pi_c)(\pi_v\Delta_v+\pi_c\Delta_c)} \\
&\quad -\frac{(\pi_v\Delta_v w_c - \pi_c\Delta_c w_v)((\pi_v q_i + \pi_c^- - \pi_v^-)\Delta_v + (\pi_c q_i + \pi_c^- - \pi_v^-)\Delta_c)}{(\Delta_c+\Delta_v)(\pi_v-\pi_c)(\pi_v\Delta_v+\pi_c\Delta_c)} \\
&= -\frac{(w_c+w_v)(\pi_c^- - \pi_v^-)\Delta_c\Delta_v}{(\pi_v-\pi_c)(\pi_v\Delta_v+\pi_c\Delta_c)} \\
&< 0
\end{aligned}$$

If (23) is violated, $\frac{\mathrm{d}W}{\mathrm{d}(p_c+p_v)}$ may be positive, but may also still be negative: suppose that (23) is violated but is an approximate equality. Then $\frac{\mathrm{d}W}{\mathrm{d}(p_c+p_v)}$ is greater than, but still approximately equal to $-\frac{(w_c+w_v)(\pi_c^- - \pi_v^-)\Delta_c\Delta_v}{(\pi_v-\pi_c)(\pi_v\Delta_v+\pi_c\Delta_c)}$. The term $\frac{\mathrm{d}W}{\mathrm{d}(p_c+p_v)}$ is thus still negative which means that social welfare decreases as an effect of the new policy although the number of permissions granted increases. Only if M increases more, so that $\frac{\partial q_i}{\partial(p_c+p_v)}$ is substantially larger than the upper bound defined by the right hand side of (23), social welfare will increase as a consequence of the new policy.

Now consider the case where the Nash equilibrium is (and remains) of type (c). Then $p_c + p_v$ necessarily increases when limits to the duration of the administrative licensing procedure are imposed. Suppose for the moment that $u'(\cdot)$ remains unchanged. Again, the number of permissions granted may increase or decrease since

$$\begin{aligned}
\frac{\mathrm{d}M}{\mathrm{d}(p_c+p_v)} &= \frac{\mathrm{d}((q_g+q_i)p_c + q_g p_v)}{\mathrm{d}(p_c+p_v)} \\
&= \frac{\mathrm{d}\left(\frac{p_c+p_v}{\Delta_v}\left(1(\Delta_v - \tilde{e}u'(\cdot)) + q_g\tilde{e}u'(\cdot)\right)\right)}{\mathrm{d}(p_c+p_v)} = \frac{\mathrm{d}\left(\frac{p_c+p_v}{\Delta_v}\left(\Delta_v - q_i\tilde{e}u'(\cdot)\right)\right)}{\mathrm{d}(p_c+p_v)} \\
&= \frac{1}{\Delta_v}\left(\Delta_v - q_i\tilde{e}u'(\cdot)\right) - \frac{(p_c+p_v)q_i^2}{\Delta_v}\tilde{e}^2 u''(\cdot) \qquad (26)
\end{aligned}$$

may be positive or negative, depending on the exact shape of $u(\cdot)$ and its derivatives. Note that $q_i = \frac{\pi_v^+ - \pi_c^+}{\pi_v^+ - \pi_v^-}$ and $q_g \frac{\pi_c^+ - \pi_v^-}{\pi_v^+ - \pi_v^-}$ are unaffected by the new policy and sum up to 1 as long as the equilibrium stays of type (c) and therefore are treated as parameters which are independent of $p_c + p_v$. The reason for a possible decrase in M is that the new policy not only increases the number of applications (this effect is expressed in the first term of line (26)) but also shifts the plans of applicants from legal to illegal ones (this effect is expressed in the second term of line (26)). Formally the latter effect results from an increas in the value of $u'((p_c+p_v)q_i\tilde{e})$ which by the first equation in condition (10b) implies an increase in $\frac{p_v}{p_c+p_v}$. Obviously, this latter effect becomes stronger, if the new policy also affects the function $u'(\cdot)$ as argued in the text. Hence the more the time limit policy directly increases the administrators' marginal disutility of effort the less will the number of permissions granted increase (or the more will it decrease).

Now look at the welfare effects. Assume the new policy does not affect the function $u'(\cdot)$ and that $\frac{\mathrm{d}M}{\mathrm{d}(p_c+p_v)} < 0$ i.e. that

$$\frac{(p_c+p_v)q_i}{\Delta_v}\tilde{e}^2 u''(\cdot) > \frac{1}{\Delta_v q_i}\left(\Delta_v - q_i\tilde{e}u'(\cdot)\right) \tag{27}$$

Then the welfare effect is negative:

$$\begin{aligned}
\frac{\mathrm{d}W}{\mathrm{d}(p_c+p_v)} &= \frac{\mathrm{d}\left(\frac{p_c+p_v}{\Delta_v}\Big((q_g+q_i)(\Delta_v - \tilde{e}u'(\cdot))w_c - q_g\tilde{e}u'(\cdot)w_v\Big)\right)}{\mathrm{d}(p_c+p_v)} \\
&= \frac{1}{\Delta_v}\left(1(\Delta_v - \tilde{e}u'(\cdot))w_c - q_g\tilde{e}u'(\cdot)w_v\right) - \frac{(p_c+p_v)q_i}{\Delta_v}\tilde{e}^2u''(\cdot)(w_c + q_g w_v) \qquad (28) \\
&< \frac{\left((\Delta_v - \tilde{e}u'(\cdot))w_c - q_g\tilde{e}u'(\cdot)w_v\right)q_i - \left(\Delta_v - q_i\tilde{e}u'(\cdot)\right)(w_c + q_g w_v)}{\Delta_v q_i} \\
&= -(w_c + w_v)\frac{q_g}{q_i} < 0
\end{aligned}$$

If the new policy does affect the function $u'(\cdot)$ the proof is very similar: An additional term describing this effect would occur both in line (26) and in the formula in line (28). As with the term associated to $u''(\cdot)$ this additional term would cancel via inequality (27). Only if the number of permissions granted increases as a result of the new policy, may the welfare effect be positive. The case that the number of permissions granted happens to be constant can be incorporated in the same way as the corresponding borderline cases which occurred earlier. □

D Proof of Proposition 3

To prove that the number of applications increases if the fine is large enough, note that for equilibria of type (a) the first two terms of equality (11b′) increase if the fine is sufficiently large since they form a polynomial of degree two in f with a positive coefficient of f^2. Thus with sufficiently large fines, all values of $p_c + p_v$ may satisfy equality (11b′) as long as they are smaller than $\frac{1}{q_i\tilde{e}}$ (otherwise $w(\cdot)$ would become infinite). An increase of the fine f also decreases the maximum value of q_i which still satisfies condition (10a′) which implies $q_i \leq \frac{\pi_v^+ - \pi_v^-}{\pi_v}$ (I use the same abbreviations as in the proof of proposition 2). As a consequence, with increasing fines, the restriction $p_c + p_v < \frac{1}{q_i\tilde{e}}$ becomes less and less restrictive, so that all $p_c + p_v \leq 1$ may be achieved by a sufficiently large fine. If the equilibrium is of type (c), the very same effects work: increasing f reduces the equilibrium q_i determined by equality (10a′) and at the same time moves equality (11b′) up. One can thus achieve all values of $p_c + p_v$ by a sufficiently large fine, which of course also includes the value which the limit on the duration of the administrative procedure achieves.

I will now show that the welfare effect of the fine is in general better than the effect of the limit on the duration of the procedure. I start with the case in which the equilibrium is and remains of type (a) before and after the imposition of the fine system. Suppose for the moment that the function $u'(\cdot)$ is not affected by limits on the duration of the licensing procedure and note that it is not affected by the fines system. Then both policies reach the same q_i, if the fine is adjusted so that the number of applications is the same. Note that not only q_i and p_c+p_v are the same but due to equality (10b) p_c and p_v are the same under both policies as well. The only difference is the equilibrium propensity to permit without investigation: while with the administration time limit system it is $q_g = q_g^{tl} = \frac{q_i\pi_c+\pi_c^- -\pi_v^-}{\pi_v-\pi_c}$ it is $q_g = q_g^f = \frac{q_i(\pi_c+f)+\pi_c^- -\pi_v^-}{\pi_v-\pi_c} = q_g^{tl} + \frac{q_i f}{\pi_v-\pi_c}$.

The effect of the two policies on social welfare $W = (q_i+q_g)p_c w_c - q_g p_v w_v$ thus differes by:

$$W^f - W^{tl} = (q_g^f - q_g^{tl})(p_c w_c - p_v w_v) = \frac{q_i f(p_c+p_v)(\Delta_v w_c - \Delta_c w_v)}{(\pi_v-\pi_c)(\Delta_c+\Delta_v)} \qquad (29)$$

Compare this to the welfare effect which increasing the number of applications by a limit on the duration of the administrative procedure has on social welfare compared to the situation prior to the policy change. To distinguish between the equilibrium number of applications as well as the equilibrium probability of investigation before and after the introduction of the new policy, I write $p_c^o + p_v^o$ and q_i^o for the equilibrium values before the change and p_c+p_v and q_i for the equilibrium values thereafter. Then the effect of the policy on social welfare is:

$$\begin{aligned} W^{tl} - W^o \;=\; & (p_c+p_v)\,\frac{(q_i\pi_v+\pi_c^- -\pi_v^-)\Delta_v w_c - (q_i\pi_c+\pi_c^- -\pi_v^-)\Delta_c w_v}{(\pi_v-\pi_c)(\Delta_c+\Delta_v)} \\ & -(p_c^o+p_v^o)\,\frac{(q_i^o\pi_v+\pi_c^- -\pi_v^-)\Delta_v w_c - (q_i^o\pi_c+\pi_c^- -\pi_v^-)\Delta_c w_v}{(\pi_v-\pi_c)(\Delta_c+\Delta_v)} \\ =\; & \frac{\pi_v\Delta_v w_c - \pi_c\Delta_c w_v}{(\pi_v-\pi_c)(\Delta_c+\Delta_v)}\,((p_c+p_v)q_i - (p_c^o+p_v^o)q_i^o) \qquad (30) \\ & +((p_c+p_v)-(p_c^o+p_v^o))(\pi_c^- -\pi_v^-)\,\frac{\Delta_v w_c - \Delta_c w_v}{(\pi_v-\pi_c)(\Delta_c+\Delta_v)} \qquad (31) \end{aligned}$$

Remember that the first term in line (30) is positive. The second term is zero, if the new policy does not affect the function $u'(\cdot)$ since then $(p_c+p_v)q_i = (p_c^o+p_v^o)q_i^o$ remains constant due to equality (10b). If the policy does affect the function $u'(\cdot)$ then the second term becomes negative and so does the entire expression in line (30). Due to $p_c+p_v > p_c^o+p_v^o$ the term in line (31) is positive if and only if the fraction in this line is positive. Thus, if the difference in equation (29) is negative then the term in line (31) is negative and so is $W^{tl} - W^o$. In words, the time limit policy may be superior to the fines policy only if the welfare effect of the time limit policy is negative. Note that this implies that the welfare effect of the fines policy must be negative as well. Also note that the reverse is not true: even if social welfare declines as a result of the time limit policy, the fines system may still be superior and even welfare enhancing. This proves the proposition for the case that the equilibrium is and remains of type (a).

If before the policy change the game is in an equilibrium of type (c), i.e. if administrators never deny permission without having investigated the application first, the difference of the welfare effects of the two policies is ambiguous.

Again suppose that the fines are adjusted so that both policies increase the number of applications by the same amount. Then the limit on the duration of the procedure may have no effect on the equilibrium probability with which administrators investigate their cases. This is true as long as the equilibrium stays of type (c). For the fines system, this is not true however: in an equilibrium of type (c), the probability with which an administrator investigates a case is given by $q_i^f = \frac{\pi_v^+ - \pi_c^+}{\pi_v + f}$ which obviously decreases in the size of the fine. As long as the equilibrium stays of type (c), this does not affect the probability of legal plans to be granted permission: $q_i^f + q_g^f = 1$ by the definition of a type (c) equilibrium. However, the probability that illegal plans are permitted increases. This disadvantage of the fines system may (partly, completely, or more than completely) be offset by a reduction in the number of legal plans: $p_v = \frac{u'((p_c+p_v)q_i\tilde{e})}{\Delta_v}(p_c + p_v)$ by the first equation in (10b) with $p_c + p_v$ being the same number for bothe policies, but q_i being smaller under the fines system implies that p_v is smaller under the fines system than under the system of limits on the duration of licensing procedures. Whether the larger permission probability for illegal plans or the smaller number of such plans prevails depends on the exact form of the administrators' disutility of effort and must thus be treated as ambiguous. If the equilibrium changes from type (c) to type (a) as a consequence of the policy change, the unambiguous superiority of the fines system eventually offsets its possible inferiority in the range of type (c) Nash equilibria.[20]

E Proof of Propositions 4 and 5

Since proposition 5 implies proposition 4, I restrict the proof to the former. As argued in the text, incomplete redistribution of the fines to the successful applicants and complete redistribution with risk averse citizens are equivalent to each other. I therefore further restrict my argument to incomplete redistribtuion. I first formalize complete and incomplete redistribution and then show that the expected pay-offs from filing an application for any given level of q_i and the associated equilibrium level of q_g decrease in the size of the fine under the conditions stated in the proposition. This implies that the equilibrium value of $p_c + p_v$ decreases in the fines as well.

[20] A reverse alternation of equilibrium types does not occur. This is obvious for the limits on the duration of the administrative procedure. For the fines system, the upper bound of q_i, i.e. $\frac{\pi_v^+ - \pi_c^+}{\pi_v + f}$ declines slower than the equilibrium value of q_i when the fine pushes the Nash equilibrium along the function defined by both parts of equality (10b). A proof is just lots of algebra for simple queueing systems, but a general argument seems difficult.

With fines f and rewards r equations (10a) and (11b) become:

$$\begin{aligned}\bar{q}_g &= \frac{(\tau_c(\pi_c + r + f) - \tau_v(\pi_v + r + f))q_i + \pi_c^- - \pi_v^-}{\pi_v - \pi_c} \\ &\leq 1 - \frac{\pi_v^+ - \pi_c^+}{(1-\tau_c)(\pi_c + r + f) - (1-\tau_v)(\pi_v + r + f)}\end{aligned} \tag{10a$''$}$$

and

$$\begin{aligned}&0 \leq q_i \tfrac{(\pi_c+r+f)(\pi_v+r+f)(\tau_c-\tau_v)}{\pi_v-\pi_c} + \tfrac{(\pi_v^+ + r)(\pi_c^- - f) - (\pi_c^+ + r)(\pi_v^- - f)}{\pi_v - \pi_c} \\ &-k^o - c(q_i\tilde{e} + w(p_v + p_c, q_i\tilde{e}; \cdot))\,.\end{aligned} \tag{11b$'''$}$$

where I use the usual abbreviations $\pi_v = \pi_v^+ - \pi_v^-$ and $\pi_c = \pi_c^+ - \pi_c^-$.

Note that the total amount of the fines is given by the size of the fine, multiplied by the expected number of denied permissions, and the total amount of the rewards by the size of the reward, multiplied by the number of permissions granted. Denote the difference between the total fines collected and the total rewards awarded by:

$$\delta = f \cdot ((p_c + p_v)q_d + (p_c(1-\tau_c) + p_v(1-\tau_v))q_i) - r \cdot ((p_c + p_v)q_g + (p_c\tau_c + p_v\tau_v)q_i)$$

For any given $q_i < \frac{\pi_v^+ - \pi_c^+}{(1-\tau_c)(\pi_c+r+f)-(1-\tau_v)(\pi_v+r+f)}$ and $q_d = 1 - q_i - q_g$ as well as $p_c/p_v = \Delta_v/\Delta_c$ this implies after some basic algebra:

$$(r+f)^2 q_i(\tau_c - \tau_v) = (\pi_v^+ - \pi_c^+)f - (\pi_c^- - \pi_v^-)r - (r+f)\frac{(\pi_v\Delta_v + \pi_c\Delta_c)}{\Delta_c + \Delta_v}(\tau_c - \tau_v)q_i - (\pi_v - \pi_c)\delta$$

Insert the latter equation into (11b$'''$) to get:

$$q_i\frac{(\tau_c - \tau_v)\pi_c\pi_v}{\pi_v - \pi_c} + \frac{\pi_v^+\pi_c^- - \pi_c^+\pi_v^-}{\pi_v - \pi_c} + q_i\frac{(\tau_c - \tau_v)\pi_c\pi_v}{\pi_v - \pi_c}\frac{\pi_v\Delta_v + \pi_c\Delta_c}{\Delta_c + \Delta_v}(r+f) - \delta \tag{32}$$

for the first two terms of equation (11b$'''$).

Thus with complete redistribution of the fine ($\delta = 0$), the first two terms of equation (11b$'''$) become larger. This allows the remaining terms of (11b$'''$) to become larger as well, and thus that $p_c + p_v$ becomes larger as well. Note that $p_c + p_v$ remains constant if $\tau_v = \tau_c$.

However with incomplete redistribution of the fine $\delta > 0$, the first two terms of equation (11b$'''$) become strictly smaller if the correlation between the type of a plan and its legal merits is sufficiently small. Note that there is an upper bound of $r + f$ for every given q_i due to the equilibrium condition $q_i \leq \frac{\pi_v^+ - \pi_c^+}{(1-\tau_c)(\pi_c+r+f)-(1-\tau_v)(\pi_v+r+f)}$ which results from (10a$'''$).

References

Andreoni, James; Erard, Brian; and Feinstein, Jonathan (1998): "Tax Compliance" Journal of Economic Literature, Vol.36, 818-860

Fudenberg, Drew and Tirole Jean (1992): "Game Theory"

Gabel, H. Landis and Sinclair-Desgagné, Bernard (1993): "Managerial Incentives and Environmental Compliance" Journal of Environmental Economics and Management, Vol.24, 229-240

Graetz, Michael J.; Reinganum, Jennifer F. and Wilde, Louis L. (1986): "The Tax Compliance Game: Toward an Interactive Theory of Law enforcement" Journal of Law, Economics, and Organization, Vol.2, 1-32

Holler, Manfred J.(1993): "Fighting Pollution when Decisions are Strategic" Public Choice, Vol. 76, 347-356

Holmstrom, Bengt and Milgrom, Paul (1991): "Multitask Principal–Agent Analysis: Incentive Contracts, Asset Ownership, and Job Desidn" Journal of Law, Economics, and Organization, Vol.7, Sp. Issue, 24-52

Itoh, Hideshi (1994): "Job Design, Delegation and Cooperation: A Pricipal Agent Analysis" European Economic Review, Vol.38, 691-700

Laffont, Jean-Jacques and Tirole, Jean (1993): "A Theory of Incentives in Procurement and Regulation" Cambridge, MASS, and London England: The MIT-Press

Laffont, Jean-Jacques and Jean Tirole (1990): "The Politics of Government Decision Making: Regulatory Institutions" Journal of Law, Economics, and Organization, Vol.6, 1-31

McCubbins, Noll, and Weingast (1987, 1989, 1999)

Moe (1987, 1989)

Philipson, Tomas J. and Posner, Richard A.: "The Economic Epidemiology of Crime", Journal of Law and Economics Vol 39, 1996, 405-433

Rasmusen (1994) [textbook]

Tirole, Jean (1986): "Hierarchies and Bureaucracies: On the Role of Collusion in Organizations" Journal of Law, Economics, and Organization, Vol.2, 181-214

Tirole, Jean (1994): "The Internal Organization of Government" Oxford Economic Papers, Vol 46, 1-29

Tsebelis, George (1989): "The Abuse of Probability in Political Analysis: The Robinson Crusoe Fallacy" American Political Science Review, Vol.83, 77-91

Tsebelis , George (1993) : "Penalty and Crime: Further Theoretical Considerations and Empirical Evidence" Journal of Political Politics, Vol.5, 349-374

Tullock, Gordon: "Economics of Income Redistribution" Boston: Kluwer-Nuhuff: 1983 von Wangenheim, Georg (1998): "Eindämmung Opportunistischen Verhaltens in der öffentlichen Verwaltung: Das Problem des 'Anfütterns' bei Korruptionsdelikten" in: Die Präventionswirkung zivil- und strafrechtlicher Sanktionen, Ed.: Claus Ott und Hans-Bernd Schäfer, Tübingen: J.C.B. Mohr (Siebeck) 1998, 238-264

von Wangenheim, Georg (1999): "Production of Legal Rules by Agencies and Bureaucracies" in: Bouckaert, Boudewijn and De Geest, Gerrit (eds.): Encyclopedia of Law and Economics. Aldershot, Edward Elgar