Mitigation of Inefficient Strategic Behavior Prior to Court Decisions

Habilitation thesis

submitted to and accepted by the Faculty of Economics and Management

of the Otto-Von-Guericke University Magdeburg

in partial fulfillment of the requirements for the academic degree

doctor habilitatus

by

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Submitted on 28th November 2023

Defended on 30th October 2024

C o n t e n t s :

1. Introductory Note

1. INTRODUCTORY NOTE

"The prophecies of what the courts will do in fact, and nothing more pretentious, are what I mean by the law." – OLIVER WENDELL HOLMES (1897)[1]

In his famous address to the Supreme Judicial Court of Massachusetts, Justice Oliver Wendell Holmes described what constitutes the law in a fashion that is very familiar to economists. Holmes rejected the idea that the law is ultimately "a system of reason" (Holmes 1997, p. 994), based on effortful deductions from general principles. He explained that what matters to people in the end is only to know how the courts will decide a given case. This perception of the law resembles the theory of expectations formation in modern economics, as "economic plans have to be put into operation on the basis of judgments about an uncertain future" (Kantor 1979, p. 1426). Until today, economists and many law-and-economics scholars have studied the impact of legal rules on individual behavior in this manner: a rational decision-maker is expected to comply with the law if the expected costs of a violation, for example through a punishment, exceed the expected gains of compliance. This economic approach has provided researchers with a tried and tested toolbox to analyze laws and the enforcement system regarding their ability to facilitate desirable social behavior.

A potential caveat of such a modelling approach, however, is the treatment of courts as a black box, as mere adjudicative "*Automaten*" in the words of Max Weber (1922, p. 664) which mechanically enforces legal consequences with exogenous probabilities. It assumes

[1] Copyrighted by Holmes in 1897, (re-)published as Holmes (1997), p. 994.

away possible strategic behavior in and outside courtrooms, and thus neglects any relevance of this strategic behavior for the outcome. In the worst case, this simplifying assumption may even jeopardize the analytical findings: contrasting decision theory to game theory, Tsebelis (1991) demonstrated for the field of regulatory enforcement that policy recommendations may be radically different if one allows for the strategic interaction between the regulated firms and the enforcement agency: if courts are treated as an exogenous enforcement risk (the "black box"), then an increase in the level of sanctions increases corporate compliance. If the enforcement agency is regarded as a genuine player in the interaction, higher sanctions reduce the frequency of law enforcement in equilibrium (see Tsebelis 1991, p. 91).

Having to choose between these different modelling approaches, theorists need to consider the scope of the research at hand. The game-theoretical perspective appears particularly promising whenever the number of economic agents is small and each agent´s choice matters for the other agents (see Fudenberg/Tirole, 1999, p. xviii).[2] Given the strategic nature of litigation, i.e., usually two legal contestants competing for the favor of an impartial arbitrator, "the judicial process is tailor-made for investigations by the theory of games" (Schubert 1958, p. 1022). Over the years, scholars from the economics, legal and political sciences have used game theory to both enhance our understanding of the legal justice systems and to reveal inefficiencies caused by strategic behavior of the players.

[2] Not surprisingly, this intuition is similar for models of competitive markets. Firms may act as 'price-takers' in the anonymous market, or they may attempt to react to their known competitors by choosing 'best responses.'

In the following papers, I contribute to the literature by exploring the mitigation of inefficient strategic behavior prior to court decisions. Using a variety of game-theoretical models, I will address a selection of three prominent ("classic") research topics in the economics of litigation. The chosen topics will cover distinct fields of law, i.e., civil law, corporate law, and criminal law. For each of these topics, I will identify an inefficiency caused by strategic behavior prior to court decisions and seek to determine how this inefficiency can be mitigated. The proposed remedies relate to adjudicative practices, institutional design, or even the limited rationality of a player.

i.) The first chosen "classic" research topic in the economics of litigation is court delay and the length of legal proceedings. Court delay is commonly regarded as one dimension of court performance (see Voigt 2016), and longer trials are deemed inefficient as they are associated with delayed justice. In the paper "*Disposition time and the utilization of prior judicial decisions: Evidence from a civil law country*" (Berlemann/Christmann 2020), we hypothesize that litigants have less opportunities for strategic behavior during court proceedings and thus judges are quicker to render a decision when similar disputes have been decided previously by courts. In a two-stage rent-seeking game, we find that the parties indeed exert less rent-seeking effort in the subgame-perfect equilibrium when the judge can verify the case at lower effort costs, i.e., when previous court decisions on a matter are readily available. Based on hand-collected cross-section data from a German trial court, we substantiate our theoretical claim through regression analysis. We find that the availability of prior judicial decisions contributes to a statistically significant and sizeable reduction in the length of trial. Previous literature traditionally emphasizes the efficiency-

enhancing role of judicial decision-making for the common-law (so-called "efficiency of the common law"-hypothesis", see Rubin 1977). Our analysis thus yields the first empirical evidence of such an efficiency effect of prior judicial decisions ("precedents") for a civil-law country.

The dataset was originally collected during my dissertation and used in two previous papers of my Ph.D.-thesis. However, the two previous papers studied whether judges react to the anticipated probability of appeal (see Berlemann/Christmann 2016) and when cases show a higher probability for an in-court settlement (see Berlemann/Christmann 2019). The analysis involved OLS and logistic regression models. The present paper is clearly distinct from the Ph.D. project: we address a different research question, use a different dependent variable, some new controls, and apply Poisson and negative binomial regression models.

ii.) The second topic under scrutiny originates from the field of corporate law and focuses on corporate takeovers and post-deal shareholder litigation. While so-called 'squeeze-out'-laws are intended by lawmakers to facilitate favorable takeovers of widely held corporations, the possibility of shareholder litigation and a judicial 'price fairness review' allegedly hinder takeovers (see Croci et al., 2017). The paper "*Takeovers, shareholder litigation, and the free-riding problem*" (Broere/Christmann, 2021) applies a sequential takeover game with many shareholders and one corporate buyer. We thereby demonstrate that not the use of legal remedies by strategic shareholders prevents the potential takeover, but flaws in the design of squeeze-out laws (such as laws that define different majority thresholds for the success of takeovers and squeeze-outs) and flaws in the

judicial procedures to determine the fair market value of the firm. Interestingly, a change in jurisdiction of the German Federal Supreme Court in 2010 coincided with the reasoning of our model when the court corrected an inefficiency.

iii.) The third "classic" topic in the economics of litigation is the institution of plea bargaining in adversarial justice systems. Such plea deals imply that the prosecutor and the defendant in a criminal proceeding agree on a guilty plea by the defendant in exchange for a reduced sentence. For economists, a very desirable feature of this bargain is the revelation of hidden information about the defendant´s true guilt through the self-selection of the guilty defendants for the deal (see Grossman/Katz 1983). Despite the widespread implementation of plea deals in countries around the world, particularly German legal scholars argue that plea bargaining is not compatible with the inquisitorial justice system (see, e.g., Rönnau 2018).

In the paper "*Prosecution and Conviction under Hindsight-Biased Information Updating in Adversary Legal Systems*" (Christmann, 2021), I reject the traditional self-selection model as unsatisfactory for two reasons: first, those models rely on 'black box'-courts and thus exogenous probabilities of enforcement. This would require that the performance of the prosecutor in court and her confidence in the defendant´s guilt is not degraded by the self-selection of the guilty defendants before trial. This appears questionable as it implies that the prosecutor is about to face mainly innocent defendants in trial, and this should affect both the prosecutor´s behavior and the probabilities of finding the defendants guilty. Second, those models rely on a perfectly Bayesian prosecutor. To tackle these points, I extend the basic signaling model by introducing a litigation

tournament as the last stage of the game. Furthermore, I integrate a formal framework of biased Bayesian updating to capture the so-called hindsight bias. Hindsight-biased agents tend to believe more strongly in what they observe than a rational decision-maker would do (see, e.g., Fischhoff, 1975, p. 288), and many researchers regard this bias as a substantial problem in the correct interpretation of criminal evidence (see, among others, Garoupa 2012).

Given this setup, I show that the performance of the prosecutor in the perfect Bayesian equilibrium hinges on reputational concerns: the more the prosecutor fears to lose a case in court, the tougher are the negotiated plea deals for the guilty defendants, but the less cases the prosecutor will take to court. The effect of hindsight bias largely depends on what kind of information causes the bias: if the biased prosecutor gets bolder, this amplifies the self-selection process. If the hindsight bias reduces the prosecutor´s confidence in the case, however, then the separating equilibrium in the tradition of Grossman/Katz (1983) may actually collapse.

In order to discuss the implementation of plea bargaining in inquisitorial justice systems, the paper "*You go first!: coordination problems and the burden of proof in inquisitorial prosecution*" (Christmann/Kirstein 2022) presents a game-theoretic framework for inquisitorial criminal procedures: we stylize a game in which a strategic interaction between two impartial investigating agents, the prosecutor and the judge, leads to potentially inefficient equilibria. These problems of effort coordination between the players can induce excessive costs and potentially wrongful convictions. Incentivizing the prosecutor to avoid losing in court may solve this problem, if and if only the prosecutor is

not opportunistic and does care about court errors. Raising the burden of proof ("beyond reasonable doubt") cannot improve effort coordination, but at least reduces the probability of wrongful convictions and this effect is not sensitive to the (potentially unknown) prosecutor´s true type.

Finally, in the paper "*Plea Bargaining and Investigation Effort: Inquisitorial Criminal Procedure as a Three-Player Game*" (Christmann 2023), I take the above considerations one step further and introduce the defendant as the third player to the prosecution game. Furthermore, the judge is now able to offer a plea deal to the defendant and end the game before court proceedings start. The applied solution concepts are the sequential equilibrium and Selten´s trembling-hand perfect equilibrium. My analysis shows that the introduction of plea bargaining solves the above discussed problem of effort coordination and yields the first-best outcome. Furthermore, wrongful convictions are now avoided in equilibrium, but this comes at the cost of some wrongful acquittals. I also discuss several extensions of the basic model to consider critical points identified in the literature, such as attorney moral hazard, different timings of deals and opportunistic prosecutors. The positive features of plea bargaining are robust to several variations of the basic inquisitorial model.

Robin Christmann Hasede, November 2023

2. REFERENCES

[1] Berlemann, Michael, and Robin Christmann. 2016. Do judges react to the probability of appellate review? Empirical evidence from trial court procedures. *Applied Economics Letters* 23: 202-205.

[2] Berlemann, Michael, and Robin Christmann. 2019. Determinants of in-court settlements: empirical evidence from a German trial court. *Journal of Institutional Economics* 15: 143-162.

[3] Berlemann, Michael, and Robin Christmann. 2020. Disposition time and the utilization of prior judicial decisions: Evidence from a civil law country. *International Review of Law and Economics* 62: 105887.

[4] Broere, Mark, and Robin Christmann. 2021. Takeovers, shareholder litigation, and the free-riding problem. *International Review of Law and Economics* 65: 105951.

[5] Christmann, Robin. 2021. Prosecution and Conviction under Hindsight-Biased Information Updating in Adversary Legal Systems. *Journal of Institutional and Theoretical Economics* 177: 404-427.

[6] Christmann, Robin. 2023. Plea Bargaining and Investigation Effort: Inquisitorial Criminal Procedure as a Three-Player Game. *European Journal of Law and Economics* (forthcoming).

[7] Christmann, Robin, and Roland Kirstein. 2022. You go first!: coordination problems and the burden of proof in inquisitorial prosecution. *European Journal of Law and Economics*: 1-20.

[8] Croci, Ettore, Eric Nowak, and Olaf Ehrhardt. 2017. The corporate governance endgame–minority squeeze-out regulation and post-deal litigation in Germany. *Managerial Finance* 43: 95-123.

[9] Fischhoff, Baruch (1975), "Hindsight ¤ Foresight: The Effect of Outcome Knowledge on Judgment under Uncertainty," *Journal of Experimental Psychology: Human Perception and Performance*, 1(3), 288–299.

[10] Fudenberg, Drew, and Jean Tirole. 1999. *Game Theory*. Cambridge: MIT press.

[11] Garoupa, Nuno (2012), "The Economics of Prosecutors," in: Alan Harel and Keith N. Hylton (eds.), Research Handbook on the Economics of Criminal Law, Edward Elgar Publishing, Northampton (MA), pp. 231–242.

[12] Grossman, Gene M., and Michael L. Katz. 1983. Plea bargaining and social welfare. *The American Economic Review* 73: 749-757.

[13] Holmes, Oliver Wendell. 1997. The Path of the Law. *Harvard Law Review* 110: 991-1009.

[14] Kantor, Brian. 1979. Rational Expectations and Economic Thought. *Journal of Economic Literature* 17: 1422-1441.

[15] Rönnau, Thomas. 2018. Das deutsche Absprachenmodell auf dem Prüfstand – zwischen Pest und Cholera. *Zeitschrift für Internationale Strafrechtsdogmatik* 5/2018: 167-177.

[16] Rubin, Paul. 1977. Why is the common law efficient? *Journal of Legal Studies* 6: 51-63.

[17] Schubert, Glendon. 1958. The Study of Judicial Decision-Making as an Aspect of Political Behavior. *American Political Science Review* 52: 1007-1025.

[18] Tsebelis, George. 1991. The Effect of Fines on Regulated Industries. Game Theory vs. Decision Theory. *Journal of Theoretical Politics* 3: 81-101.

[19] Voigt, Stefan, 2016. Determinants of judicial efficiency: a survey. *European Journal of Law and Economics* 42: 183–208.

[20] Weber, Max. 1922. *Grundriß der Sozialökonomik. III. Abteilung. Wirtschaft und Gesellschaft*. Tübingen: J.C.B. Mohr (Paul Siebeck).

2. Disposition Time and the Utilization of Prior Judicial Decisions.
(International Review of Law & Economics 62: 105887)

International Review of Law and Economics 62 (2020) 105887

Contents lists available at ScienceDirect

International Review of Law and Economics

Disposition time and the utilization of prior judicial decisions: Evidence from a civil law country

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ARTICLE INFO

Article history:
Received 25 May 2019
Received in revised form
30 September 2019
Accepted 3 January 2020
Available online 2 February 2020

JEL classification:
K15
K40
K41

Keywords:
Legal citation
Jurisprudence constante
Case resolution
Court delay
Precedent

ABSTRACT

Court delay frustrates economic behavior. This paper examines the nexus between the case disposition time and the availability of prior court decisions for the civil law. We model litigation as a rent-seeking game, and find that prior court decisions curb strategic behavior in similar cases. Thus, the excessive use of party resources in litigation, such as time, is reduced if prior decisions clarify the interpretation of the law. Using judge-level data, we provide empirical evidence on a potential role of such 'precedents' for case disposition time in a civil law country. Our results show that the availability of prior decisions contributes to a significant reduction in disposition time. Moreover, the reduction in the duration of trials becomes stronger when the stock of previous court decisions grows. We conclude that the utilization of prior judicial decisions plays a crucial role for the efficiency of justice also in civil law countries.

1. Introduction

In both common and civil law systems, courts are the primary institution for dispute resolution. All economic agents, individuals and corporate entities, have the right to bring their claims before a court and enforce their rights. However, the access to courts remains theoretical if courts do not deliver judgments within a reasonable period of time. In the case of a dispute, the involved parties aim at clarifying a legal situation at hand by obtaining a final decision. Any delay in legal proceedings keeps the involved parties in a protracted state of uncertainty that may be considered akin to a denial of justice. One thus might interpret delayed justice as denied justice.

Lengthy court proceedings have direct economic impacts. Slow judicial enforcement reduces the present value of monetary and non-monetary punishments in consequence of defaults on contractual agreements (Chemin, 2009a). In the case of credit markets, court delay might induce more borrowers to default as they might expect that creditors will not be able to recover their loans quickly through judiciary procedures (Japelli et al., 2005). As a consequence, creditors might reduce credit, leading to less investment and economic prosperity. Empirical evidence tends to support this line of argument. Djankov et al. (2003) construct an index of procedural formalism of dispute resolution for 109 countries, based on an evaluation of the exact procedures used by litigants and courts to evict a tenant for nonpayment of rent and to collect a bounced check. The authors find this index to be positively correlated to average case disposition time, judicial unfairness and corruption. Chemin (2009b) shows for the example of a judicial reform in Pakistan that a decrease in the case disposition time (here by training measures) led to an increase of the entry rate of firms by 50 percent and additional growth in a range of 0.5 percent of the gross domestic product. Chemin (2009a) employs data on a judicial reform in India and shows that a speeding up of case disposition time improves credit market performance and increases aggregate output, especially in the farming sector, where credit markets play a decisive role. Visaria (2009) shows that the introduction of debt recovery tribunals in India led to a speeding up of the processing of debt recovery suits and caused reduced delinquencies and lower interest rates at constant borrower quality.

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https://doi.org/10.1016/j.irle.2020.105887
0144-8188/

Against the background of the described negative consequences of court delay, research in the determinants of the length of trials is urgently necessary. While the literature has already identified a number of different factors influencing case disposition time, the legal doctrine of jurisprudence constante ('ständige Rechtsprechung') has yet received little attention. In contrast to precedents in the common law tradition, judicial decisions in civil law systems have no binding authority. Under jurisprudence constante, the emergence of repeated and uniform court verdicts in analogous cases over time creates a persuasive impact on future judicial decisions. Consequently, court decisions may generate a legal certainty "that codifications have failed to achieve" (Fon and Parisi, 2006, p. 522). Nevertheless, adjudication evolves on demand, not gradually, and while such judicial law-making may have consolidated some subfields of law, other kinds of disputes lack previous jurisdiction and hang in the balance.

In this paper we analyze the nexus between the availability of prior judicial decisions[1] and case disposition time in the civil law. As a theoretical reference, we specify a two-stage rent seeking game between the litigants and the judge in the tradition of Tullock (1975). In our model, judges are motivated to decide correctly and parties may spend effort on improving their chances of winning the trial. Given this setting, we show that the availability of prior decisions on similar cases should particularly decrease rent-seeking effort of the litigants, and thus reduce case disposition time. We also show that the availability of prior decisions should increase the accuracy of the resulting verdicts. In the second step of our analysis we test our model empirically, based on data from a civil law country, a law system which is known to have more procedural formalism of dispute resolution than common law countries (Djankov et al., 2003). More precisely, we employ a unique dataset of case records from a German trial court and present empirical evidence in favor of the hypothesis that prior court decisions on similar cases shorten trials. We also study whether utilization of multiple prior decisions by the trial judge have an impact on process length. Our findings support the theoretical argument of Fon and Parisi (2006) that prior judicial decisions in civil law countries may play a subtler, but comparably beneficial role for legal efficiency as known from legal precedents in the common law.

The paper is organized as follows. In section 2, we provide a brief review of the literature on court delay. The theoretical framework is presented in section 3. Section 4 describes the available dataset and delivers some descriptive statistics. In section 5, we present and discuss the estimation results. Section 6 concludes.

2. Related literature

The evaluation of court performance and thus of the efficiency of the installed enforcement mechanisms have always been major topics in the law and economics literature. Several researchers have proposed different approaches to further categorize the broad term of court performance (see, among others, Tullock, 1980; Dakolias, 1999; Staats et al., 2005 and Voigt, 2016). One dimension of court performance is court delay. We concentrate our subsequent review of the growing literature on this dimension. The empirical literature seeks to identify court delay either by analyzing aggregate data on the output per court (or judge), or by studying impact factors for the disposition time of individual cases on the micro-level.

The first strand of empirical research concentrates on the output of courts or judges. Output is often measured by clearance rates, congestion rates, resolved cases and average disposition time, and then applied to cross-court or cross-country analyses (among many others, see Djankov et al., 2003, Japelli et al., 2005; Chemin, 2009a, b; Dimitrova-Grajzl et al., 2012). Despite the limitations of such studies for an analysis of case-level factors, such as the availability of prior court rulings, several findings appear remarkable to our research. For instance, Rosales-López (2008) applies an ANOVA approach to annual case resolutions, workload and reversal rates of Spanish courts. She finds that an increase in case resolutions per period does not necessarily lead to an increase in reversals. In a different paper, Dimitrova-Grajzl et al. (2016) study determinants of case disposition time in Bulgarian courts and identify a major demand side influence on court output. The authors conclude that a legal policy that simply increases the size of the judiciary may not reduce case disposition time. For the case of Germany, Schneider (2005) measures the output of judges by case resolution and the extent of lawmaking. By doing so he intends to account for the production of precedents, which "change the content of the law as applied in practice" (Schneider, 2005, 130), by including the number of published decisions in the legal electronic database JURIS. He finds that judges with a pH.D. are more productive, but are also reversed more often. The author suggests that pH.D. judges more frequently dissent from precedents, and thus the reversal rate increases. Interestingly enough, his results also show that judges with a higher promotion probability are less productive and more often reversed.

The use of aggregate data implies that the related empirical studies cannot draw further inference from peculiarities of the individual lawsuit. In order to overcome this problem, the second strand of the literature focuses on case-level determinants of case disposition time by courts. Several studies have confirmed that legal representation by advocates, multiple parties on defendant or plaintiff side, the number of witnesses, oral hearings and the use of expert opinions significantly increase case disposition time (Priest, 1989; Bielen et al., 2015; Grajzl and Zajc, 2016). Particular types of disputes, i.e. malpractice cases, or particular types of parties, such as a defending corporate entity, are also potential explanatory factors for prolonged dispute resolution (Heise, 2000). Normative complexity in the code of law may further delay court decisions (Di Vita, 2012), as it becomes more difficult for the judge to interpret and apply the set of legal rules. Furthermore, the individual characteristics of the judge may play a role for trial length. Ramseyer (2012) provides evidences for a strong impact of elite education on judicial productivity and speed in handling cases. He also suggests that experience does matter less for the individual judge, but more on the institutional level (the court). Bielen et al. (2017) analyze data from a Belgian trial court and observe a positive effect of the judgeś age and a negative effect of job experience on case disposition time. Examining a twenty-five-year-sample from US appeal courts, Christensen and Szmer (2012) find both factors to prolong trials, though only experience (tenure) is significant. Other studies have identified a relevant impact of court organization and procedure. Dalton (2009) reveals an interaction between court size and the number of attorneys, with larger courts working more efficiently with few advocates and, surprisingly, vice versa. Fenn and Rickmann (1999) study medical malpractice claims and find an increased duration of lawsuits whenever legal aid was provided to one party.

Micro-level analyses thus have provided fruitful insights into case-specific and procedural impact factors of case disposition time. One factor which has yet received little attention is whether previous jurisdiction on the legal conflict at hand is available. We

[1] Some European authors apply the term precedent also to previous court rulings in codified law countries (e.g., Schneider, 2005; Fon and Parisi, 2006), and court rulings may show similar features in both legal systems. However, there is no common understanding or guideline about what turns a court ruling into a legal precedent in civil law countries. In the following, we will thus reserve the term precedent for the common law, and speak of *prior judicial decisions* or *'precedent'* in the civil law context.

should expect that the existence of prior court decisions has an influence on the length of court procedures as they can serve the judge as a guideline for his or her verdict. Thus, whenever prior judicial decisions exist, we should expect shorter trials. To the best of our knowledge, the only study dealing at least partially with this issue is the one by Chemin (2009a).[2] He reports that temporarily conflicting judicial decisions taken in India due to the Code of Civil Procedure's ambiguity lead to a higher expected trial duration. The author attributes this finding to the fact that judges have to spent considerable time on choosing between several conflicting legal views.

3. A rent-seeking model with prior judicial decisions

3.1. Setup

Rent-seeking games (see, e.g., Tullock, 1975) provide a basic framework for the analysis of court proceedings when litigants behave strategically. In these models, parties seek to obtain a common rent, the disputed value, and can influence the probability of winning with private effort. It is the well-known contribution of this literature to show that total resources, spent in such games, may consume a major part of the rent while the probability of success remains unchanged in equilibrium. Rent-seeking games primarily capture the adversary nature of a legal dispute, and resemble a "*trial by battle*" (Tullock, 1975, p.746).

In order to analyze the effects on case disposition time, the rent-seeking effort of each litigant is interpreted as the time spent on the case, such as writing statements of claims, rebut allegations of the opposing party, assemble favorable evidence, prepare witnesses and attend court hearings. Thus, time spent on a legal dispute produces an inefficiency (delay) when court accuracy, that is the probability of a correct verdict, remains unaffected. For simplicity, we will focus on this rent-seeking perspective of litigation effort. In the following, we apply an adaptation of the Tullock (1975) model to study litigation and case disposition time under a civil law regime.

Consider a litigation game with three players, the litigants Mr. Right and Mr. Wrong, and the judge. We assume that the litigated case is not trivial, meaning that the court ruling is not ex-ante perfectly determined by the legal and factual nature of the case.[3] Mr. Right and Mr. Wrong may thus exert costly effort to increase their probabilities of winning the case. This captures the adversarial feature of litigation procedures. While the decision of the judge implies uncertainty, the names of the litigants indicate to the reader that Mr. Right should prevail in court whenever the judicial decision is perfectly accurate.[4]

While adversarial legal systems rely heavily on the litigants to substantiate their claims in the courtroom, the judge plays a more active role in investigating the case in civil law countries. We capture this inquisitorial nature of civil law systems and introduce the judge as the third maximizing decision-maker to the Tullock game. The judge may increase accuracy on his own, but this consumes more time to evaluate the presented evidence, interrogate witnesses and assess the legal situation. In the resulting non-cooperative game, all players maximize expected returns and choose optimal efforts.

For reasons of simplicity, we assume that initially both litigants have the same probability of winning the case. Furthermore, Mr. Right and Mr. Wrong are equally able to increase their chances of success, given that the judges exert no judicial effort to evaluate the presented claims. Let R (W) be the time spent on the case by Mr. Right (Mr. Wrong), both of which are trivially non-negative, and J be the verification level chosen by the judge. The probability of winning for Mr. Right can then be written as

$\frac{(J+1)\cdot R}{(J+1)\cdot R+W}$ with $R,\ W,\ J \geq 0$ and $R \vee W > 0$.

Mr. Wrong then wins with probability $\frac{W}{(J+1)\cdot R+W}$.

A higher judicial verification level obviously increases the probability that Mr. Right prevails and makes his effort in persuading the judge also more effective. Symmetrically, the more the judge studies the legal case and the provided evidence, the less effective is the effort of Mr. Wrong in achieving a favorable verdict. In other words, the behavior of both parties influences the court outcome, but it is easier for Mr. Right to convince an investigative judge of his rightful claim. Given this setup, the court is fully arbitrary if J = 0 and parties exert the same effort in equilibrium. Assuming that the court cannot perform worse than throwing a dice, it follows that $J \geq 0$.

The timing of the presented litigation game is divided into two stages: the legal battle of the litigants (stage 1), and the decision-making of the judge (stage 2). At stage 1, Mr. Right and Mr. Wrong enter the rent-seeking game and choose their effort R and W simultaneously. Both litigants have to form rational expectations about the behavior of the adversary, and the verification level chosen by the judge. At stage 2, the judge then assesses the presented evidence and chooses his verification level in order to achieve an accurate verdict. The outcome of the chosen strategies is the profit Π_R and Π_W for Mr. Right and Mr. Wrong, and the utility UJ for the judge. Equilibrium strategies can be identified via backward induction.

3.2. Stage 2: the judge

In a civil law regime, the judge plays an active role in solving the case (inquisitorial system). He processes the factual evidence brought forward by the litigants, but also interrogates witnesses or inquires expert assessment on complicated technical or medical matters. In addition to the assessment of the facts of a case, the judge has also to interpret the applying legal rules. Given that abstract legal rules rarely perfectly fit a real world problem, the interpretation of the law is difficult and requires judicial effort. Eventually, the judge renders a professional opinion based on the provided evidence and the law.

We assume that the judge is motivated to solve a given case correctly and receives a benefit B as the consequence of an accurate decision. Thus, he should decide in favor of Mr. Right in our model. However, a higher judicial verification level exhibits diminishing marginal returns, as it becomes more and more exhausting to further increase the probability of a correct decision. Note that the efforts of the litigants affect the task of the judge in opposing ways: while more effort by Mr. Right makes it easier to reveal the truth, the effort of Mr. Wrong turns it more complicated.[5] Furthermore, there are marginal costs *mc* of the judicial verification level.

[2] Several studies examine the effect of published decisions on the reputation of the judge and his influence among the judiciary (e.g. McCormick and Praskach, 1996; Solimine et al., 1998; Klein and Morrisroe, 1999; Smyth and Bhattacharya, 2003; Choi et al., 2011), but do not focus on court performance. Similarly, the study of Landes and Posner (1976) offers resourceful insights into the formation and depreciation of precedents, but does not connect them to court performance.

[3] Otherwise, we would expect rational parties to settle outside the court (case selection) and save court resources. Furthermore, a perfectly determined case leaves little room for rent-seeking behavior, and the Tullock model would not be appropriate.

[4] In this regard, the 'right' decision can simply be interpreted as being aligned with the higher courtś jurisdiction on comparable cases. Following the literature (see, for an overview, Polinsky and Shavell, 2007, pp.282), we assume that for a given level of enforcement costs, a more accurate court decision is always socially preferable.

[5] Clearly, the judge cannot know the true nature of Mr. Right and Mr. Wrong, but we believe it reasonable to assume that the judge is able to observe how his accuracy production is contingent on given party behavior. We later show that the parties exert equal effort in equilibrium, thus in equilibrium the judge could neither

The higher these marginal costs, the more time the judge requires for a given increase in the verification level. Marginal costs may be affected by case complexity, imprecision of legal rules or the existence of previous jurisdiction on a similar case. The maximization problem for the judge is then given by

$$U_J(J) = B \cdot \frac{(J+1)\cdot R}{(J+1)\cdot R + W} - J \cdot mc(\theta) \underset{J}{\Rightarrow} \max!$$

Consider that the availability of prior decisions θ affects marginal costs negatively. If there is a previous court decision to a comparable case, this establishes an interpretation of the law and provides a line of legal argumentation and exemplified requirements on factual evidence for the judge. By using the prior court decision, the judge saves resources (and thus costs) for a given level of verification, as he does not have to logically deduce the legal assessment himself, consider legal doctrines or a hypothetical intent of the lawmaker.

The first-order-condition yields the optimal verification level J*, which is

$$J^*(R,W) = \frac{\sqrt{\frac{BRW}{mc(\theta)}} - W}{R} - 1 \tag{1}$$

A maximizing judge would thus increase the verification level, if marginal costs *mc* diminish. We find it plausible to assume that prior court rulings reduce marginal costs for the judge. The judge will then be able to compare the facts of the case at hand to the previous jurisdiction. The result is a higher accuracy (in accordance with the previous decision). Judicial verification also increases if the motivation of the judge for a correct decision B is higher. Eq. (1) also shows how the judge reacts to an increase in effort by Mr. Right and Mr. Wrong in an optimal manner. One would assume that a judge would gradually increase the verification level in order to restore accuracy if Mr. Wrong spends more resources on the case. Similarly, it appears plausible that a judge could reduce the judicial verification level if Mr. Right spends more resources and thus "proves the case himself". While this is indeed largely the reaction of the judge described here, however, this result cannot be generalized. Whenever Mr. Right exerts very little effort, but Mr. Wrong further and further increases his use of resources, marginal costs exceed the marginal benefit and it becomes optimal for the judge to invest less in the case.

3.3. Stage 1: rent-seeking

The litigants will form rational expectations about the behavior of the judge. Given a disputed value D (the "rent"), Mr. Right and Mr. Wrong decide simultaneously how much effort they spend on the case. For simplicity, we set marginal effort costs of the parties equal to one.[6] Consider that both parties will form an expectation on the amount of resources, spent by the opposing party. Given this setup, the expected returns of Mr. Right, Π_R, and Mr. Wrong, Π_W, can be described as the following maximization problems:

$$\Pi_R(R) = D \cdot \frac{(J^*(R,W)+1)\cdot R}{(J^*(R,W)+1)\cdot R + W} - R \underset{R}{\Rightarrow} \max! \tag{2}$$

$$\Pi_W(W) = D \cdot \frac{W}{(J^*(R,W)+1)\cdot R + W} - W \underset{W}{\Rightarrow} \max! \tag{3}$$

Inserting the optimal judicial effort (1) into (2) and differentiating with respect to R yields the first-order condition, which gives the reaction function for Mr. Right, R*(W).

$$R^*(W) = \sqrt[3]{\frac{\frac{1}{4}D^2 \cdot W \cdot mc(\theta)}{B}} \tag{4}$$

The interpretation for Mr. Right is straightforward: he increases his litigation effort if the value in dispute D is higher or if his adversary, Mr. Wrong, invests more. The same applies for Mr. Right if the judge is less motivated to achieve accuracy and Mr. Right has to exert more effort to substantiate his claim. Also, higher marginal costs of the judge imply less judicial verification and require Mr. Right to invest more resources.

Inserting (1) into (3) and differentiating with respect to W delivers the first-order condition for Mr. Wrong and gives the reaction function, W*(R).

$$W^*(R) = \frac{D^2 \cdot mc(\theta)}{4 \cdot B \cdot R} \tag{5}$$

Mr. Wrong will also increase his litigation effort if the disputed value D increases or if the judge is less dedicated to verify the case. Again, higher marginal costs of the judge lead to higher effort. In contrast to symmetric rent-seeking models, however, Mr. Wrong will also spend *less* resources on litigation if Mr. Right increases his effort. This is due to the externality of the endogenous enforcement mechanism: if Mr. Wrong also increases his effort, this is costly to him and also provokes the judge to better evaluate the case, which is favorable for Mr. Right. If Mr. Wrong reduces his efforts, this saves costs and leads to less judicial verification, which weakens the position of his adversary.

3.4. Outcome

The Nash-equilibrium of the litigation game is the combination of mutual best responses by Mr. Right and Mr. Wrong, given the expected behavior of the judge. As a special case, the game equals the standard Tullock contest without judicial verification if the judge exerts no effort in equilibrium (J = 0), which occurs only for high marginal costs, $4 \cdot mc(\theta) \geq B$. Solving (5) for R and equating with (4) yields equal equilibrium party effort

$$W^* = R^* = \begin{cases} \dfrac{D \cdot \sqrt{mc(\theta)}}{2\sqrt{B}}, & \text{if } J > 0 \Leftrightarrow B > 4 \cdot mc(\theta) \\ 1/4D, & \text{if } J = 0 \Leftrightarrow B \leq 4 \cdot mc(\theta) \end{cases} \tag{6}$$

For the interesting case of judicial verification, J > 0, the litigants play the established equilibrium strategies and the total effort costs of litigation are given by $mc(\theta) \cdot J* + R* + W*$. Using (1) and (6) specifies total effort costs, TEC, as

$$TEC = mc(\theta) \cdot \left(\sqrt{\frac{B}{mc(\theta)}} - 2 \right) + \frac{D\sqrt{mc(\theta)}}{\sqrt{B}}, \quad \text{if } J > 0 \tag{7}$$

Obviously, total effort costs TEC depend on the marginal costs of the judge to verify the case. For the first summand, identifying judicial effort costs, an increase in $mc(\theta)$ shows an ambiguous effect on effort costs: Higher marginal costs may be compensated by a lower level of verification. We call this the direct effect of a change in $mc(\theta)$, as it applies to the judge. The second summand indicates total party expenditures and clearly increases in $mc(\theta)$. We call this the strategic effect of a change in $mc(\theta)$. To analyze the total effect, we form the first derivative and find $\frac{\partial TEC}{\partial mc} > 0$ for $\left(\frac{D+B}{4\sqrt{B}}\right)^2 > mc(\theta)$, which is always fulfilled for $D \geq B > 4 \cdot mc(\theta)$. This implies that as long as the motivation of the litigants to obtain a favorable verdict (the "rent" D) is at least as high as the motivation of the judge, B, and judicial verification is generally favorable, J > 0, then an increase in

distinguish the two litigants based on the observed effort, nor is his equilibrium effort contingent on party effort.

[6] The model can easily be extended by allowing for diverging marginal effort costs. In this regard, one would expect that the availability of a prior court decisions potentially reduces effort costs for Mr. Right and increases marginal costs for Mr. Wrong. Our findings then become even more pronounced, as total effort costs decrease stronger in equilibrium if previous court decisions exist.

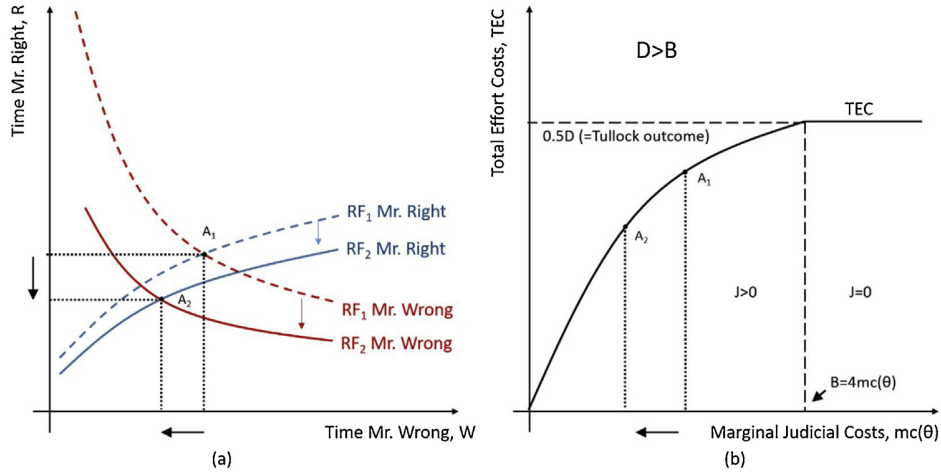

Fig. 1. Effect of prior rulings on rent-seeking (a) and total effort costs (b).

judicial verification costs also leads to higher total effort costs TEC.[7] Conversely, if marginal costs for the judge decrease, e.g. through an available previous court ruling, then total effort costs of litigation decrease as well.

Eqs. (6) and (7) show that, for $D \geq B$, such prior decisions are beneficial because they lead to fewer resources spent on rent-seeking in equilibrium. In particular, this analysis reveals an unambiguous strategic effect of the availability of prior decisions, as rent-seeking opportunities in the courtroom are effectively restricted.

Fig. 1 illustrates the impact of previous court decisions on a similar matter on rent-seeking and total litigation expenditures: In the left diagram, the reaction functions of Mr. Right and Mr. Wrong shift from RF_1 to RF_2 due to an available previous court ruling. This decreases equilibrium rent-seeking efforts. The diagram on the right then shows the favorable reduction in total litigation expenditures by the three players. As indicated above, we interpret all resources invested by the players as time consuming. Consequently, a reduction in total effort costs means a reduction in the time needed for litigation. We find it reasonable to assume that this effect (at least partially) leads to a reduction of case disposition time.

Furthermore, a prior court decision also leads to an increase in accuracy of the court. Given the equilibrium strategies R*, W* and J* of the three players, the probability of a correct verdict (in favor of Mr. Right) can be calculated as $1 - \frac{\sqrt{mc(\theta)}}{\sqrt{B}}$, *if* $J > 0$. A decrease in marginal costs for the judge (or a higher motivation of the judge) increases the probability that Mr. Right wins.

Based on our model, we thus form the following testable *presumption*: if previous judicial decisions on a legal matter are available, case disposition time decreases.

4. Data

In order to study the previously hypothesized impact of prior judicial decisions on case disposition time empirically, we use a dataset from a German first instance trial court (Amtsgericht), located in Hamburg.[8] First instance courts primarily evaluate the facts of a case and apply the law made by the legislator and specified by higher courts. Consequently, we should expect that first instance courts benefit most from available previous court decisions in terms of a shorter disposition time.

The data is a random draw out of all civil law cases that were filed at the court in 2009, and consists of 2360 full case records.[9] However, we had to drop cases that were resolved without a judicial verdict, e.g. via default judgment (37 percent), withdrawal (24 percent) or in-court settlement (12 percent). One might argue that, by dropping all these cases, we factually study not all cases in which prior judicial decisions might affect individual behavior. For example, the existence of previous decisions might induce litigants to drop their cases, achieve a settlement or not to file any case at all. However, as we have no information on the relevance of prior decisions in these cases, we have to restrict our analysis to cases where a verdict was written and, consequently, can also draw conclusions only for these cases. We might interpret this as a quite conservative estimation approach as the effects of prior judicial decisions might be even larger outside the courtroom.

Our final sample thus consists of 576 first instance court rulings. In 139 cases, the decision was appealed. Litigants later withdrew 54 appeals without a final decision of the higher instance court. Eventually, the appeals court confirmed the first instance verdict (in 76 cases) or overruled it (in 9 cases).

Our empirical approach explores the previously established *presumption* that the utilization of previous court decisions leads to shorter case disposition time. We thus estimate a regression model explaining the length of a court proceeding by the availability of prior decisions and a number of additional case-specific control variables. In the following, we present the response variable, our measure of prior decisions, and the applied set of control variables.

The response variable DURATION identifies the disposition time of a court proceeding, measured in months. The average length of trials that ended in a court ruling turns out to be 6.2 months, which is slightly below the state (7.2 months) and country average (7.1 months) in 2009 (see Statistisches Bundesamt, 2009). Fig. 2 displays the distribution of DURATION in our sample.

As we aim at studying the impact of prior judicial decisions on trial length, we need appropriate measures for the existence and relevance of previous court decisions in the cases included in our dataset. Because there is no objective measure of the existence of

[7] Otherwise, the judge is incentivized to overinvest resources in the Tullock game, and the total effect of a change in marginal costs on TEC becomes ambiguous. However, we find $D \geq B$ to be plausible for most litigated cases and thus only a mild restriction.

[8] The court district covers about 190.000 inhabitants and is a representative court for the city of Hamburg with respect to court size, population and proceedings. The district includes upper class residences, working class quarters and industrial areas.

[9] We chose the year 2009 as it was the oldest and most complete volume in the archive with almost no missing or pending cases.

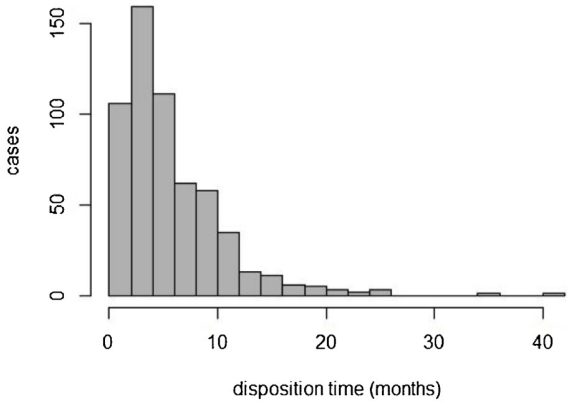

Fig. 2. Distribution of DURATION.

such decisions in a legal dispute, we focus on judicial citations in the verdict as indicators for the existence and relevance of prior judicial decisions.[10] First, we code a dummy variable PREV_DECISION, which takes on the value of one whenever the judge cited a previous decision in the legal reasoning of the verdict. Second, we use dummies to capture cases with one citation, two citations, and three or more citations of previous judicial decisions.[11]

As control variables, we employ different, likely relevant characteristics of the tried case. We base our choice of controls mostly on the related literature on case disposition time (see, e.g., Fenn and Rickmann, 2013; Bielen et al., 2015; Grajzl and Zajc, 2016), however, are restricted by the availability of the referring variables in our dataset.

First, we control for the involvement of advocates on the side of the plaintiff and the defendant by the two dummy variables P_ADVOCATE and D_ADVOCATE. If a case is to be concluded by a judicial verdict, then we expect it to take longer whenever the parties involve advocates, as doing so increases the complexity of communication. Moreover, legal representation may create an agency problem, as advocates are usually less interested in short proceedings.[12]

Second, we control for the legal nature of the involved parties by the two dummy variables P_FIRM and D_FIRM. Firms typically are more rational in filing suits, have more experience in handling legal issues than private individuals and thus (on average) can be regarded as repeat players (see Galanter, 1974). Moreover, they have the ability to solve the earlier discussed potential agency problem by relying on internal advocates or repeatedly cooperating with the same external law firm. We therefore expect that firms on the plaintiff and/or defendant side will lead to shorter trials.

Third, the specific subfield of law might have an influence on trial length. It thus seems to be useful to control for the various subfields of civil law included in our dataset. More precisely, we control by dummy variables for cases from contract law (CONTRACTS), tenancy law (TENANCY), traffic law (TRAFFIC) and tort law (TORTS). All remaining cases are grouped in the category "OTHER".

Fourth, trial length might be correlated with the value in dispute. One might expect that trials with higher values in dispute also lead to lengthier trials. We therefore control for the value in dispute in our regressions (VALUE).

Fifth, we control for oral hearings by including an additional dummy variable (ORAL). It has the value of one whenever at least one oral hearing took place. While oral hearings might contribute to a higher probability of an early settlement (Berlemann and Christmann, 2016), it will likely increase the length of a trial when a settlement cannot be reached as the process of scheduling and holding court hearings is time consuming. We therefore expect a positive coefficient for oral hearings.

Sixth, we control for appealability of a case by the dummy variable APPEALABILITY, which equals one if the case can be appealed at the higher court level. One might expect that the litigants exert more effort in such proceedings as this effort might be helpful in a subsequent appeal and could provide a head start at the higher level. However, one could also argue that the litigants conserve effort at lower instance courts when they are certain of an appeal. Thus, the impact of appealability appears rather unclear.

Seventh, we seek to control for case complexity. The variable CORRESPONDENCE identifies how many pages of correspondence between the involved parties and the court were exchanged. This variable links case complexity also to the partyś aggressiveness to pursue a legal claim, but may also indicate the provision of valuable information to the judge (see Bielen et al., 2019). Overall, we rather expect extensive correspondence to lead to longer trials. The variable GROUNDS captures the extent of the judgeś legal reasoning when documenting the decision by indicating the length of the legal grounds in the verdict, as measured in words. In addition, we identify the amount of legal literature (LITERATURE) and legal norms (LEGALNORMS_No) cited by the judge in the legal reasoning. While the use of legal literature, norms and the extent of written grounds are also a question of personal style by the judge, for which we control in the regressions, these factors are clearly related to the underlying complexity of the case. We thus presume that the length of trial increases when more literature and norms are cited, and the legal grounds become more extensive.

Table 1 reports some summary statistics on the employed dataset.

For our sample, the parties to the dispute were represented by advocates in most proceedings. The majority of cases involved at least one corporate entity, and stem from the field of contract law. Three out of four cases included oral hearings of the parties, and more than half of the first instance verdicts were indeed appealable. A typical case involved about seventy pages of party correspondence with the court, and resulted in seven hundred words of judicial reasoning. Previous court decisions were cited in less than fifty percent of the court rulings, and then hardly more than one previous court decision was mentioned by the judge.

5. Estimation results

In the following, we study empirically whether the availability of prior decisions speeds up trials. As our explanatory variable, case disposition time (DURATION), is a count variable with comparatively low count values (as disposition time is measured in months), we refrain from using the standard linear regression approach but instead opt for a generalized linear regression model (GLM). More precisely, we employ the Poisson regression approach. In order to deal with possible overdispersion, we estimate the model with robust standard errors. To control for judge-specific effects, we estimate all models with judge-fixed effects.

We start out with a model explaining case disposition time by judge-fixed effects (captured by the vector J), the earlier described control variables (captured by the vector C) and the dummy vari-

[10] This is a natural caveat of legal research. However, we believe that judges will tend to cite prior decisions if they are available. Trial judges can expect that appellate judges are on average more knowledgeable about relevant prior court decisions than themselves. Then, not citing a relevant verdict will give rise to doubts about the trial judgeś proficiency, and thus at least expose the trial verdict to a more thorough scrutiny. As citation patterns may differ between judges, we will apply a fixed effect model in our subsequent empirical analysis.

[11] The distribution of verdict citations is strongly right-skewed with up to 22 citations in one case. Consequently, we use categories instead of a continuous variable.

[12] Note that cases that are dropped or settled due to an advocateś advice are not in our dataset, as we focus on cases that are concluded by a judicial verdict.

Table 1
Descriptive Statistics of Dataset.

Variable	Description	Mean	Median	Min	Max
DURATION	months between filing and first-instance verdict	6.19	5	0	42
PREV_DECISION (dummy)	Previous decisions were cited	0.42			
PREV_DEC_One	One previous decision cited	0.16			
PREV_DEC_Two	Two previous decisions cited	0.07			
PREV_DEC_More	More than two previous decisions cited	0.19			
P_ADVOCATE (dummy)	Plaintiff is represented by an advocate	0.92			
D_ADVOCATE (dummy)	Defendant is represented by an advocate	0.73			
P_FIRM (dummy)	Plaintiff is a firm or organization	0.44			
D_FIRM (dummy)	Defendant is a firm or organization	0.33			
CONTRACTS (dummy)	Case in the field of contract law	0.51			
TORTS (dummy)	Case in the field of tort law	0.04			
TENANCY (dummy)	Case in the field of tenancy law	0.22			
TRAFFIC (dummy)	Case in the field of traffic law	0.17			
OTHER (dummy)	Case in other field of law	0.05			
VALUE	Value in dispute (Euro)	1838	1046	12	40000
ORAL (dummy)	Oral hearings were held	0.76			
APPEALABILITY (dummy)	Verdict can be appealed	0.66			
CORRESPONDENCE	Party correspondence to court (pages)	70.25	49	1	414
GROUNDS	Legal grounds as presented in verdict (words)	700	576	0	4968
LITERATURE (dummy)	Legal literature was used in reasoning	0.30			
LEGALNORMS_No	Number of legal norms used in reasoning	8.50	7	0	40

Table 2
Impact of Prior Judicial Decisions on the Duration of Trials.

	Baseline model (1)		Extended model (2)	
	coefficient, (se)	marginal effect	coefficient, (se)	marginal effect
PREV_DECISION	−0.172**	−1.06		
	(0.069)			
PREV_DEC_ONE			−0.128	−0.79
			(0.079)	
PREV_DEC_TWO			−0.165*	−1.02
			(0.085)	
PREV_DEC_MORE			−0.230**	−1.42
			(0.089)	
P_ADVOCATE	0.177**	+1.09	0.184**	+1.14
	(0.083)		(0.084)	
D_ADVOCATE	0.133*	+0.82	0.136*	+0.84
	(0.072)		(0.073)	
P_FIRM	−0.142**	−0.88	−0.138**	−0.85
	(0.065)		(0.064)	
D_FIRM	0.001	0.00	0.002	+0.01
	(0.060)		(0.060)	
TORTS	0.140	+0.87	0.136	+0.84
	(0.096)		(0.098)	
TENANCY	0.024	+0.15	0.017	+0.11
	(0.085)		(0.083)	
TRAFFIC	0.040	+0.25	0.038	+0.23
	(0.074)		(0.074)	
OTHER	−0.366***	−2.26	−0.357***	−2.21
	(0.106)		(0.105)	
VALUE	−0.00000	0.00	−0.00000	0.00
	(0.00001)		(0.00001)	
ORAL	0.191**	+1.18	0.196**	+1.21
	(0.092)		(0.092)	
APPEALABILITY	0.292***	+1.80	0.284***	+1.76
	(0.075)		(0.076)	
CORRESPONDENCE	0.004***	+2.47	0.004***	+2.47
	(0.001)	(per 100 pages)	(0.001)	(per 100 pages)
GROUNDS	0.00003	+0.02	0.00003	+0.02
	(0.0001)	(per 100 words)	(0.0001)	(per 100 words)
LITERATURE	0.045	+0.28	0.045	+0.28
	(0.060)		(0.060)	
LEGALNORMS_No	0.011	+0.07	0.012*	+0.07
	(0.007)		(0.007)	
Judge-fixed effects?	Yes		Yes	
Pseudo R Squared (McFadden)	0.543		0.545	
Observations	576		576	

Significance levels: '***'<0.01; '**'<0.05; '*'<0.1; We report robust, judge-clustered standard errors in brackets.

able PREV_DECISION, which accounts for the availability of previous court decisions in the case at hand. Thus we estimate the Poisson-model

$$DURATION_i = \exp(\alpha J_i + \beta C_i + \gamma PREV\_DECISION_i + \varepsilon_i)$$

with ε being the unexplained residual. The estimation results are shown in Table 2. We report the estimated coefficients, standard errors and the average marginal effects (expressed in months).

For most of the control variables, the signs of the estimated coefficients have the expected signs. Furthermore, eight out of 16 coefficients are significantly different from zero. As expected, the involvement of advocates increases case disposition time significantly. Whenever the plaintiff is supported by an advocate, the process on average takes 1.1 months longer. A similar but slightly smaller effect is found for the defendant (+0.8 months). Trials with firms as plaintiffs on average last 0.9 months less than those where the plaintiffs are private individuals. The subfield of law turns out to have little systematic effect on trial length. We find no significant differences of cases from tort law, tenancy law or traffic law from the reference category of contract law. Only the category covering other fields of law delivers a significantly shorter case disposition time (-2.3 months). The value in dispute has no significant effect on case disposition time. As expected, law suits with at least one oral hearing last significantly longer than those without oral hearings (+1.2 months). Appealable cases go along with 1.8 months longer disposition times. An increase in the correspondence between the parties and the court of 100 pages is associated with longer trials (+2.5 months). We find no effect of the cited legal literature or cited legal norms.

Our variable of interest, the citation of prior decisions, shows a negative impact which is statistically significant at the five percent level. We find that cases have a 1.1 month shorter disposition time when judges cite at least one previous court decision. Our analysis thus supports our *presumption* of the earlier outlined theoretical model, and provides first empirical evidence that such 'precedents' significantly speed up civil law suits at the trial court.

In our regression model, we controlled for prior judicial decisions by including a dummy variable for cases in which at least one court ruling was cited. However, we did not distinguish between the case where only one prior decision is available and cases, where multiple rulings are cited in the verdict. While the distribution of judicial decision citation in verdicts is strongly right-skewed, with a majority of cases not referring to previous decisions at all and about another 20 percent of the verdicts including one or two citations only, verdicts with up to 20 cited court rulings occur in our dataset. We explore the impact of citing multiple verdicts on disposition time by using a dummy variable for each category of one, two, and three or more citations (see the extended model in Table 2). All three estimated coefficients are negative. While the coefficient for the dummy for one previous decision is marginally insignificant, the other two coefficients turn out to be significantly different from zero. Remarkably the marginal effects and the significance level increase steadily from the citation of just one previous court decision to citing three or more court decisions. We thus might conclude that a growing number of 'precedents' shows a stronger negative effect on case disposition time as the law becomes more consolidated by courts. This finding supports the idea by Fon and Parisi (2006) who proposed a theoretical model of civil law evolution in which the state of law is determined by the stock of established precedents. In their model, precedents become persuasive in a civil law country once an institutional threshold is met. Our finding would suggest that already a rather limited number of court rulings on a specific matter shows a sizable impact on future trial court decisions, which further increases with the growing stock of 'precedents'.

Table 3
Robustness Checks.

	Reduced model (3)	Negative binomial (4)
PREV_DECISION	−0.152**	−0.172**
	(0.070)	(0.069)
P_ADVOCATE	0.179**	0.177**
	(0.078)	(0.083)
D_ADVOCATE	0.146**	0.133*
	(0.068)	(0.072)
P_FIRM	−0.156***	−0.142**
	(0.053)	(0.065)
D_FIRM		0.001
		(0.060)
TORTS		0.140
		(0.096)
TENANCY		0.024
		(0.085)
TRAFFIC		0.040
		(0.074)
OTHER	−0.395***	−0.366***
	(0.097)	(0.106)
VALUE		−0.00000
		(0.00001)
ORAL	0.213**	0.191**
	(0.090)	(0.092)
APPEALABILITY	0.283***	0.292***
	(0.069)	(0.075)
CORRESPONDENCE	0.004***	0.004***
	(0.0004)	(0.001)
GROUNDS		0.00003
		(0.0001)
LITERATURE		0.045
		(0.060)
LEGALNORMS_No	0.013**	0.011
	(0.005)	(0.007)
Judge-fixed effects?	Yes	Yes
Pseudo R Squared (McFadden)	0.540	0.543
Observations	577	576

Significance levels: '***'<0.01; '**'<0.05; '*'<0.1; We report robust, judge-clustered standard errors in brackets.

In order to study the stability of our results, we ran a number of additional regressions. First, we repeated all estimations under the inclusion of only those control variables which turned out to be significantly different from zero (see the left column of Table 3). The results remained qualitatively unchanged by this procedure. We also applied a different method of correcting for overdispersion, and applied a negative binomial regression model (see e.g. Kleiber and Zeileis, 2008; Christensen and Szmer, 2012). Again the results remain qualitatively similar (see the right column of Table 3).

6. Conclusions

Delayed court decisions have a direct and negative economic impact. While many researchers have taken a closer look into the performance of courts on the aggregate level, in cross-regional or cross-country studies, the relevance of a coherent jurisdiction for the timely resolution of legal disputes has so far received surprisingly little attention. This is particular remarkable for the case of civil law countries where a court verdict is not binding for another court per se, but gains a persuasive power only through subsequent analogous decisions over time. With regard to trial length, the utilization of prior judicial decisions appears to play a role similar to precedents in the common law. Understanding this impact of prior judicial decisions on the behavior of litigants and trial judges is thus a prerequisite for the adequate assessment of the case disposition time by courts. This paper aims at closing this gap in the literature, and to our knowledge provides first empirical evidence on the role of such 'precedents' for case disposition time in a civil law country.

As a theoretical reference, we employ a two-stage rent seeking game between the litigants and the judge. In this setup, the litigants

choose their effort simultaneously to increase their probability of winning the case, and then the judge exerts costly effort to render a correct decision. We assume that provided a previous court decision exists, it becomes easier for the judge to evaluate an analogous case correctly. We find that total litigation effort, and in particular the extent of possible rent seeking in court, is considerably reduced in the presence of prior court rulings on a similar matter. This suggests that the availability of previous, persuasive jurisdiction to a given case decreases case disposition time by curbing the socially wasteful strategic behavior in courtroom. Moreover, the reduction in strategic behavior also increases court accuracy, i.e. the probability that the court decides correctly.

We then explore our derived presumption empirically. Using case-level data from a German trial court, we apply a poisson regression model on the duration of legal disputes. We find that prior court decisions, which were cited in a judicial verdict, show a statistically significant impact and, on average, reduce the length of trial by more than one month. Interestingly, this effect grows in size and significance level when more previous court decisions are cited. Our finding thus supports the previous theoretical literature suggesting that a higher stock of legal 'precedents' consolidates the civil law.

Our empirical results further substantiate the debate on the efficiency effects of judge-made law and the evolution of judicial 'precedents' in civil law countries. Though it is commonly agreed that prior court decisions likely have a major impact on behavior outside the court, we reveal a clear effect on efficiency within litigation procedures. Our analysis thus provides additional insights for legal policy.

First, we suppose that the varying availability of prior decisions in the different subfields of law may cause diverging case disposition times. Dynamic legal fields with few judicial decisions should thus be more prone to delay and congestion problems. For example, economic agents may not be able to rely on effective court enforcement in rather innovative and changing environments, which increases transactions costs and may even impede a favorable trade. Future research has to establish whether the lawmaker can provide reasonable guidance for such dynamic legal fields, or whether other means of dispute resolution are more suitable.

Second, our findings also put into perspective a legal policy that promotes settlements. A higher settlement rate may reduce the caseload of courts, but possibly hampers the production of such 'precedents'. As a consequence, previous court decisions on a legal matter become less available and less persuasive to the litigants. As the parties react strategically and exert more rent-seeking effort, case disposition time increases. Furthermore, prior decisions also provide guidance to individuals and corporate entities outside the court, i.e. they help to coordinate the execution of numerous contracts before potential frictions arise. When the number of previous decisions declines due to higher settlement rates, more cases may actually be filed to courts.

Another implication of our theoretical model is the increased accuracy of judicial verdicts when using previous court decisions. While our dataset includes appellate procedures and a first tentative analysis showed indeed a negative effect of cited prior court decisions on the probability of reversal, the limited number of remaining observations made it impossible to rule out selection effects. We thus leave this question for future research.

Acknowledgements

We thank Jens Dammann, Nuno Garoupa, Cristina Grande-Herrera, Roland Kirstein, Roland Matthes and Sören Schwuchow for valuable comments and advice. An earlier draft of this paper was circulated under the title "The Role of Precedents on Court Delay" and presented at the 2nd Conference on Empirical Legal Studies Europe in Leuven 2018, the institutional economics committee of the German Economic Association in Lörrach 2017, the Spanish Law and Economics Conference in Madrid 2017, the German Law and Economics Conference in Marburg 2017, the Workshop on the Economics of Litigation in Paris 2017 and the Polish Law and Economics Conference in Warsaw 2017. We thank the participants and two anonymous reviewers for helpful comments and remarks. This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

References

Berlemann, Michael, Christmann, Robin, 2016. Do judges react to the probability of appellate review? Empirical evidence from trial court procedures. Appl. Econ. Lett. 23, 202–205.
Bielen, Samantha, Marneffe, Wim, Vereeck, Lode, 2015. An empirical analysis of case disposition time in Belgium. Rev. Law Econ. 11, 293–316.
Bielen, Samantha, Grajzl, Peter, Marneffe, Wim, 2017. Understanding the Time to Court Case Resolution: a Competing Risk Analysis Using Belgian Data. CESifo-Working Paper 6450. CESifo, Munich.
Bielen, Samantha, Grajzl, Peter, Marneffe, Wim, 2019. The resolution process and the timing of settlement of medical malpractice claims. Health Econ. Policy Law, forthcoming.
Chemin, Matthieu, 2009a. Do judiciaries matter for development? Evidence from India. J. Comp. Econ. 37, 230–250.
Chemin, Matthieu., 2009b. The impact of the judiciary on entrepreneurship: evaluation of Pakistan's "Access to Justice Programme". J. Public Econ. 93, 114–125.
Choi, Stephen, Gulati, Mitu, Posner, Eric, 2011. What do federal district judges want? An analysis of publications, citations, and reversals. J. Law Econ. Organ. 28, 518–549.
Christensen, Robert, Szmer, John, 2012. Examining the efficiency of the US courts of appeals: pathologies and Prescriptions. Int. Rev. Law Econ. 32, 30–37.
Dakolias, Maria., 1999. Court performance around the world. A comparative perspective. Yale Human Rights Dev. J. 2, 87–142.
Dalton, Theresa., 2009. A Matter of Size: An Analysis of Court Efficiency Using Hierarchical Linear Modeling. Unpublished Manuscript. University of Denver.
Di Vita, Giuseppe., 2012. Factors Determining the Duration of Legal Disputes. An Empirical Analysis with Micro Data. J. Inst. Theor. Econ. 168, 563–587.
Dimitrova-Grajzl, Valentia, Grajzl, Peter, Sustersic, Janez, Zajc, Katarina, 2012. Court output, judicial staffing, and the demand for court services: evidence from Slovenian courts of first instance. Int. Rev. Law Econ. 32, 19–29.
Dimitrova-Grajzl, Valentia, Grajzl, Peter, Slavov, Atanas, Zajc, Katarina, 2016. Courts in a transition economy: case disposition and the quantity-quality tradeoff in Bulgaria. Econ. Syst. 40, 18–38.
Djankov, Simeon, La Porta, Rafael, Lopez-de-Silanes, Florencio, Shleifer, Andrei, 2003. Courts. Q. J. Econ. 118, 453–517.
Fenn, Paul, Rickmann, Neil, 1999. Delay and settlement in litigation. Econ. J. 109, 476–491.
Fenn, Paul, Rickmann, Neil, 2013. Information and the disposition of medical malpractice claims: a competing risk analysis. J. Law Econ. Organ. 30, 244–274.
Fon, Vincy, Parisi, Francesco, 2006. Judicial precedents in civil law systems: a dynamic analysis. Int. Rev. Law Econ. 26, 519–535.
Galanter, Marc., 1974. Why the "Haves" come out ahead? Speculations on the limits of legal change. Law Soc. Rev. 9, 95–160.
Grajzl, Peter, Zajc, Katarina, 2016. Litigation and the timing of settlement: evidence from commercial disputes. Eur. J. Law Econ., forthcoming.
Heise, Michael., 2000. Justice Delayed? An Empirical Analysis of Civil Case Disposition Time. Working Paper. Cornell Law Faculty Publications, Ithaca, NY.
Japelli, Tullio, Pagano, Marco, Bianco, Magda, 2005. Courts and banks: effects of judicial enforcement on credit markets. J. Money Credit Bank. 73 (2), 223–244.
Kleiber, Christian, Zeileis, Achim, 2008. Applied Econometrics With R. Springer Science+Business Media., New York.
Klein, David, Morrisroe, Darby, 1999. The prestige and influence of individual judges on the US Courts of Appeals. J. Legal Stud. 28, 371–391.
Landes, William, Posner, Richard, 1976. Legal precedent: a theoretical and empirical analysis. J. Law Econ. 19, 249–307.
McCormick, Peter, Praskach, Tammy, 1996. Judicial citation, the Supreme Court of Canada, and the lower courts: a statistical overview and the influence of Manitoba. Man. LJ 24, 335–364.
Polinsky, Mitchel, Shavell, Steven, 2007. Handbook of Law and Economics, vol. 1, Amsterdam: North-Holland.
Priest, George., 1989. Private litigants and the court congestion problem. Boston Univ. Law Rev. 69, 527–559.
Ramseyer, Mark., 2012. Talent matters: judicial productivity and speed in Japan. Int. Rev. Law Econ. 32, 38–48.
Rosales-López, Virginia., 2008. Economics of court performance: an empirical analysis. Eur. J. Law Econ. 25, 231–251.
Schneider, Martin., 2005. Judicial career incentives and court performance: an empirical study of the german labour courts of appeal. Eur. J. Law Econ. 20, 127–144.

Smyth, Russel, Bhattacharya, Mita, 2003. What determines judicial prestige? An empirical analysis for the judges of the Federal Court of Australia. Am. Law Econ. Rev. 5, 233–262.
Solimine, Michael, Landes, William, Lessig, Lawrence, 1998. Judicial Influence: a citation analysis of federal courts of appeals judges. J. Legal Stud. 27, 271–332.
Staats, Joseph, Bowler, Shaun, Hiskey, Jonathan, 2005. Measuring judicial performance in Latin America. Latin American Politics and Societies 47, 77–106.
Statistisches Bundesamt, 2009. Rechtspflege 2009: Zivilgerichte. Korrigierte Ergebnisse. Fachserie 10, Reihe 2.1. Wiesbaden.
Tullock, Gordon, 1975. On the efficient organization of trials. Kyklos 28, 745–762.
Tullock, Gordon, 1980. Two kinds of legal efficiency. Hofstra Law Rev. 8, 659–669.
Visaria, Sujata, 2009. Legal reform and loan repayment: the microeconomic impact of debt recovery tribunals in India. Am. Econ. J. Appl. Econ. 1 (3), 59–81.
Voigt, Stefan, 2016. Determinants of judicial efficiency: a survey. Eur. J. Law Econ. 42, 183–208.

3. Takeovers, Shareholder Litigation, and the Free-riding Problem.
(International Review of Law and Economics 65: 105951)

International Review of Law and Economics 65 (2021) 105951

Contents lists available at ScienceDirect

International Review of Law and Economics

Takeovers, shareholder litigation, and the free-riding problem

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ARTICLE INFO

Article history:
Received 26 September 2020
Accepted 9 October 2020
Available online 5 November 2020

JEL classification:
G34
G38
K22
K41

Keywords:
Squeeze-out
Appraisals
Entire fairness
Judicial review
Takeover bids

ABSTRACT

When shareholders of a target firm expect a value improving takeover to be successful, they are individually better off not tendering their shares to the buyer and the takeover potentially fails. Squeeze-out procedures can overcome this free-riding dilemma by allowing a buyer to enforce a payout of minority shareholders and seize complete control of the target firm. However, it is often argued that shareholder litigation restores the free-riding dilemma. Applying a sequential takeover game, we examine the two standard legal remedies of shareholders, the 'action of avoidance' and the judicial 'price fairness review' and demonstrate that it is not shareholder litigation that brings back the free-riding dilemma, but rather the strategic gambling of buyers for lower prices and flaws in the design and application of squeeze-out laws. We also analyze a favorable change in jurisdiction of the German Federal Court and provide implications for legal policy.

1. Introduction

It is commonly accepted that takeovers of firms play a crucial role in the economy. Given effective competition, successful takeovers accelerate the restructuring and rightsizing of formerly weak and cost inefficient firms. Through the acquisition, buyers are able to realize synergies in production and economies of scope and scale. Furthermore, takeovers often lead to the replacement of the previous management, and this ideally favors change and a quicker adjustment to the market situation (see, among others, Yarrow, 1985; Scherer, 1988; Holmström and Nalebuff, 1992).

Many large firms in the various industries of today's economies can be regarded as widely held corporations[1] (see, e.g., Porta et al., 1998; Faccio and Lang, 2002, and Rubin, 2007), and a successful takeover often requires that a public bid from a corporate buyer is accepted by the firm's shareholders.[2] It is well known that this takeover bid mechanism is prone to a free-riding dilemma among shareholders: "any profit a raider can make from the price appreciation of shares he purchases represents a profit shareholders could have made if they had not tendered their shares to the raider" (Grossman and Hart, 1980, p. 43). As efficiency enhancing takeovers eventually lead to a higher firm value and thus higher share prices, holding out and keeping the shares will enable minority shareholders to freeride on the buyer's effort and participate in these takeover gains. Thus, shareholders will reject a public bid from the buyer when they expect the takeover to be successful and value improving. As a consequence, such free-riding behavior potentially impedes the takeover as the buyer may not collect enough shares to assume control of the target.

In order to facilitate takeovers, so-called squeeze-out procedures have become increasingly relevant for corporate buyers in many jurisdictions (e.g., United States Delaware law, European Directive 2004/25/EC, German § 327a-327f AktG). In principle, a squeeze-out[3] entitles a buyer who has collected the majority of a

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[1] In many European countries, the ownership of public companies is rather concentrated. Faccio and Lang (2002) point out that, nonetheless, roughly 37 percent of their sample of more than 5,000 corporations in 13 Western European countries can be regarded as widely held.

[2] In the United States, tender offers to the target's shareholders were typically employed in hostile takeovers. Following a 2013 change in United States Delaware law, tender offers are now employed in friendly takeovers, too (see, e.g., Boone et al., 2018).

[3] In European legislation the term 'squeeze-out' corresponds to what is frequently called a 'freeze-out' in the United States (see, e.g., Krebs, 2012, p. 941, and Subramanian, 2005, p. 5). We use these terms interchangeably, with the meaning set out in this paper.

https://doi.org/10.1016/j.irle.2020.105951
0144-8188/

company's shares and who meets a required minimum fraction of ownership (the 'squeeze-out threshold') to forcibly pay out all the minority shareholders and assume full ownership of the company.[4] As a consequence, in a tender offer for control, shareholders can no longer expect to participate in the anticipated appreciation of the share price by rejecting the bid. Squeeze-out procedures thus basically eliminate the free-riding problem (see Yarrow, 1985).

However, such squeeze-outs also enable the buyer to seize the complete gains of the takeover and force shareholders out of their investments. Most countries thus enacted specific shareholder protection laws. Standard legal remedies for shareholders include the '*action of avoidance*', which contests the legitimacy of the squeeze-out itself, and '*price fairness*'-procedures where the payout price is reviewed by the court. In the end, a court ruling can hinder or delay the squeeze-out and change the distribution of takeover gains between the buyer and the shareholders. Several scholars claim that such shareholder litigation effectively restores the free-riding problem and thus frustrates the underlying incentive mechanism of squeeze-out procedures (see, e.g., Mueller and Panunzi, 2004 and Burkart and Lee, 2018).

In this paper we focus on tender offers that are followed by a squeeze-out (i.e., 'two-step' tender offers), and examine the effects of costly shareholder litigation on the success of such takeovers. We show that shareholder protection rights and litigation induce a redistribution of takeover gains, as intended by legislators in the United States and Europe, and do not impede efficient takeovers or sizeable rents for the acquirer per se. In the following, we stylize the takeover bid mechanism as a sequential game between a corporate buyer and atomistic shareholders. In this theoretical setting, all takeovers are value improving and individual shareholders may either accept the offered price by the buyer and tender their shares, or reject it. If sufficient shares are collected in the tender phase, the buyer may announce squeeze-out procedures and, in exchange for a compensation payment, force all remaining shareholders out of the target. Shareholders may, however, move to court and seek a review of the fairness of the compensation payment by the judge. A buyer thus has to form rational expectations about the later value of litigation to shareholders, i.e. about their reservation price. In order to accomplish the takeover and eliminate any free-riding incentive, he then makes a profit-maximizing tender offer that equals this reservation price.

We find that, despite the risk of shareholder litigation, a buyer is basically able to make a tender offer at a price below the expected post-takeover share value and achieve a successful takeover. The judicial '*price fairness review*', however, compels buyers to offer higher prices to incentivize tendering and thus avoid the free-riding problem. Low costs of shareholder litigation, brief court procedures and a low discount rate work in favor of litigating shareholders. As a consequence, the required payments to eliminate free-riding increase, and it becomes costlier for the buyer to achieve a certain takeover. Our analysis shows that the free-riding dilemma in the takeover bid mechanism only re-emerges when buyers try to reduce takeover costs by using lower-than-optimal bids, when dual legal thresholds for corporate control and squeeze-outs are in place, and when the judicial price review focuses on share price fluctuations after the buyer made his public bid.

More broadly, we demonstrate that it is not shareholder litigation that restores the observed free-riding dilemma, but the strategic gambling of buyers for lower prices and flaws in the design of squeeze-out laws and judicial review. This finding applies to the two standard legal remedies of shareholders, the '*action of avoidance*' and the judicial '*price fairness review*'.[5] Previous research by Mueller and Panunzi (2004) and Burkart and Lee (2018) does not consider shareholders' litigation cost and shareholders' time preferences. They also do not take into account that, in practice, most court proceedings are ended by settlement. Our results corroborate the detrimental effect of separate legal thresholds for corporate control and squeeze-outs shown by Gomes (2012) and Dalkir et al. (2018).

The paper is organized as follows: chapter 2 provides an overview of the related literature and chapter 3 introduces the institutional background. Chapter 4 describes the stylized takeover game and derives first theoretic results. We then apply our model to a major change in the German jurisdiction on squeeze-outs in chapter 5. Chapter 6 concludes.

2. Related Literature

Following the seminal work by Grossman and Hart (1980) on the fundamental free-rider problem in takeovers, the literature in this field has discussed various solutions and aspects of the dilemma (e.g., Shleifer and Vishny, 1986; Bagnoli and Lipmann, 1988; Bebchuk, 1989; Hirshleifer and Titman, 1990; Kyle and Vila, 1991; Holmström and Nalebuff, 1992; Burkart et al., 1998; Cornelli and Li, 2002, and Amihud et al., 2003).

Our work relates to a strand of research on the effect of squeeze-out rules and shareholder litigation. Several authors have shown that, in principle, squeeze-out procedures offer a simple solution to the free-rider problem: If minority shareholders can be forced out of the firm at the price of the tender offer, free-riding (by non-tendering) is unattractive (e.g., Yarrow, 1985; Burkart and Panunzi, 2003, and Amihud et al., 2003).[6] Some authors claim that shareholder protection laws and litigation, however, frustrate this effect or even intensify the problem (see, e.g. Mueller and Panunzi, 2004 and Burkart and Lee, 2018). Mueller and Panunzi (2004) argue that shareholders will hold out in the tender offer, if there is the smallest chance that they will receive the (higher) post-takeover share value in an ensuing court ruling on the terms of the squeeze-out. Burkart and Lee (2018) generalize these results and point out that the incentive for shareholders to hold out is intensified, if the value improvement of the target firm grows with the buyer's ultimate stake in it.

One branch of research examines how separate legal thresholds for corporate control and squeeze-outs affect takeover success (see, e.g., Burkart and Panunzi, 2003; Gomes, 2012, and Dalkir et al., 2018). Gomes (2012) studies takeovers in a dynamic environment, allowing for offer revisions and trading in target shares during the takeover. His analysis shows that, when a bid is conditioned upon the buyer reaching the squeeze-out threshold, arbitrageurs can accumulate shareholdings that are large enough to jeopardize the success of the takeover and compel the buyer into pre-emptively offering a higher price. He also reasons that higher squeeze-out thresholds require higher offer prices, as less shares are required to veto the transaction, thus raising the bargaining power of arbitrageurs. Dalkir et al. (2018) find similar results in a setting where individual shareholders believe that their tendering decision might impact the success of the takeover. They find that in widely held firms separate legal thresholds will fully restore the free-riding

[4] The legal boundaries for a squeeze-out are outlined in Chapter 3.

[5] If an '*action of avoidance*' is filed, a shareholder contests the legitimacy of the squeeze-out as a whole, which may even lead to a nullification of that measure. '*Price fairness review*' puts the offered price under scrutiny.

[6] In their conclusion, Grossman and Hart (1980) already note that a second step merger or liquidation of the target firm is a common 'exclusionary device' (a mechanism that excludes minority shareholders from a part of the takeover gain, thus resolving the free-riding dilemma) in practice.

problem, as shareholders who believe that the takeover will be successful but that the squeeze-out threshold may not be achieved are better off not tendering their shares, unless they are offered (at least) the post-takeover value of shares.

3. Institutional Background

In order to understand how squeeze-outs and shareholder litigation affect the success of takeovers, we examine some of the general legal conditions that apply to these procedures. We concentrate on the institutional frameworks in the United States (Delaware law[7]) and the European Union, with some additional detail on the provisions in Germany as one example for the setting in a large member state of the European Union.[8] In 'one-step' mergers[9] the free-riding problem does not arise because the merger is binding for all shareholders (Burkart and Lee, 2018, p. 19). We therefore limit the discussion to takeovers that are broadly structured as 'two-step' tender offers for control followed by a squeeze-out of minority shareholders.[10]

In the United States, a buyer who has collected a simple voting majority in a target company (i.e., often less than fifty percent of share capital) can frequently squeeze-out the minority shareholders and assume complete control of the target (e.g., Dalkir et al., 2018; Gomes, 2012, and Krebs, 2012). Under European regulation such a buyer is required to meet a separate, more demanding threshold of ownership (often at ninety percent of share capital, or higher) before he can initiate a squeeze-out of minority shareholders (see, e.g. European Directive 2004/25/EC, § 327a-327f AktG[11], § 39a-39c WpÜG[12], and § 62 UmwG[13]).

What are the legal boundaries for the price that the buyer offers to minority shareholders in a squeeze-out? Although not expressly required, legislation provides strong incentives for buyers to offer the same price in the tender offer and the squeeze-out. In the United States, squeeze-outs that meet this condition are subjected to lower standards of judicial review (Subramanian, 2005, p. 22) and can avoid the need for shareholder approval.[14] In Europe, the *equal treatment* principle of the Takeover Directive is understood to entail that the squeeze-out price may not be lower than the price offered in a preceding bid (Kaisanlahti, 2007). Under certain conditions,[15] the tender offer price is specifically presumed to be fair for the purposes of a squeeze-out and thus unlikely to be subjected to extensive judicial review (Ventoruzzo, 2010, p. 893).

There is also no general legal requirement for the squeeze-out price to meet or exceed the market price of the target firm's shares before the squeeze-out or before an earlier bid for control. However, in the United States, '*price fairness*' procedures ensure that minority shareholders receive at least the pre-bid market price in a squeeze-out (Amihud et al., 2003, pp. 22–23). In Europe, corresponding regulations vary across national jurisdictions. In the United Kingdom, for example, the squeeze-out price may be lower than the pre-bid market price (Kaisanlahti, 2007, p. 503). In Germany, the Federal Court of Justice (BGH) holds that the average share price during a reference period of three months before the announcement date of the squeeze-out sets the lower boundary for the compensation pursuant to § 327a-327f AktG (see BGH II ZB 18/09 [2010]).[16]

In both the United States and Europe almost all squeeze-outs are subject to shareholder litigation and are eventually settled in court (see, e.g., Cain and Solomon, 2014, or Krishnan et al., 2012 for the United States, and Aders et al., 2016; Croci et al., 2017, or Gehling et al., 2007 for Europe). Standard legal remedies for shareholders include the right to appeal the squeeze-out, i.e. enforce a verification of its legitimacy ('*action of avoidance*'), and the right to apply for a judicial review on the fairness of the payout price ('*price fairness*'). The applicable conditions of shareholder litigation regarding, for example, eligibility, scope of compensation, fee allocation, and delay of completion vary considerably across jurisdictions (see, e.g., Kaisanlahti, 2007; Krebs, 2012; Restrepo and Subramanian, 2015 or Ventoruzzo, 2010 for some detail). Typically, '*actions of avoidance*' will delay the payment of the compensation while court proceedings are ongoing, whereas '*price fairness*' procedures will not (see, e.g., Krebs, 2012, and Croci et al., 2017).

Empirical results suggest that litigated takeovers in the United States have a 7.8 percent lower probability of success and, if successful, generate around 30 percent higher takeover premiums than corresponding non-litigated takeovers (Krishnan et al., 2012, p. 5). Litigation of squeeze-outs in Germany has been found to substantially raise the payout to minority shareholders: Croci et al. (2017, p. 112) show that the payout is increased by an average 26.3 percent following such litigation, whereas the increase is significantly larger in '*price fairness*' procedures (34.9 percent) than in '*actions of avoidance*' (11.3 percent). At the same time, '*price fairness*' procedures are more frequent than '*actions of avoidance*', whereas both remedies are often applied simultaneously (around 54, 9, and 37 percent of litigated squeeze-outs, respectively; Krishnan et al., 2012, p. 102).

4. Takeover model with squeeze-out Litigation

Building on the insights of Grossman and Hart (1980) and Bebchuk (1989),[17] we apply a sequential takeover game to analyze the potential conflict between the incentive mechanism of squeeze-outs in public takeover bids and shareholder litigation.

[7] We limit the judicial analyses in the United States to Delaware law under which most U.S. companies are incorporated (Amihud et al., 2003, p. 22).

[8] See, e.g., Krebs, 2012 or Ventoruzzo, 2010 for a detailed comparison of European and U.S. legislation on squeeze-outs.

[9] In a U.S. statutory merger, the merger and the squeeze-out are consummated in one step (see, e.g., Ventoruzzo, 2010).

[10] This restriction does not limit our analysis to 'hostile' takeovers. Many 'friendly' takeovers in Europe and in the United States are structured as tender offers (see, e.g., Martynova and Renneboog, 2006, p. 13, for Europe, and Offenberg and Pirinsky, 2015, and Boone et al., 2018, for the United States).

[11] German Stock Corporation Act.

[12] German Securities Acquisition and Takeover Act. The Takeover Act squeeze-out is rarely employed in practice, possibly because of untested court procedures when the buyer fails to obtain the additional ninety percent majority of minorities condition (Krebs, 2012, p. 971), or possibly because buyers seldom attain the required ninety-five percent threshold in the preceding tender offer (Allen and Overy, 2017, p. 21).

[13] German Transformation Act.

[14] § 251h Delaware General Corporation Law (DGCL) allows a buyer to effect a squeeze-out merger without shareholders' approval if he holds a majority of the listed target's share capital following a friendly tender offer for all of the target's share capital and the merger consideration is the same as the tender offer consideration.

[15] In cases of a voluntary tender offer, the consideration offered in the tender offer is presumed to be fair where, through acceptance of the bid, the buyer has acquired shares representing no less than ninety percent of the voting capital comprised in the bid. In cases of a mandatory tender offer, the consideration offered in the tender offer is unconditionally presumed to be fair (see Art. 15, Directive 2004/25/EC).

[16] This reflects a favorable change from earlier jurisdiction in Germany. We examine the effects of this change in chapter 5.

[17] Grossman and Hart (1980) identified the free-riding problem in the takeover bid mechanism and proposed that successful tender offers have to be higher than the post-takeover stock value. Bebchuk (1989) extended this analysis to takeover bids below the post-takeover stock value, which succeed with positive probability and this probability is contingent on the spread between the expected share price and the tender offer.

4.1. Assumptions

Consider a game of complete information with a unique Buyer B and N atomistic Shareholders S_i of a target firm with$i = 1, ., N$, where N is large. The target firm has an ex-ante value of V_0, which means a per share value of $V_0/N = v_0$. The target is subject to a potential takeover, and a successful buyer may cut its operating costs by reorganizing production procedures or changing the firm's current management. Thus, the firm value increases to V_1 (i.e., a value v_1 per share) if the takeover is successful. We assume $V_1 > V_0$, which implies that the takeover is socially desirable. All players are assumed to be risk neutral.[18]

In order to take over the target firm, the Buyer can make a public tender offer to shareholders with the tender price p_T per share. All tender offers in this game are unconditional. The administration of this tendering process produces constant transaction costs C_B for the Buyer. Shareholders tender X shares to the Buyer, and the takeover is successful if $X \geq \bar{k}N$. Let $0 < \bar{k} < 1$ specify the fraction of shares required for obtaining corporate control (e.g., fifty percent). If all shares are tendered, $X = N$, the Buyer obtains complete control of the target. We denote the private value of complete control as V_2 with $V_2 \geq V_1$ (or $v_2 \geq v_1$ per share, respectively). This captures the fact that complete control usually reduces the transaction costs of operating the target firm[19], and thus increases the firm value.[20]

After a successful takeover, corporate buyers are entitled to use squeeze-out procedures to buy out remaining shareholders in order to assume complete control of the firm. Initially, we assume that the Buyer may squeeze-out minority shareholders whenever the takeover is successful, that is, whenever at least $\bar{k}N$ shares are tendered.[21] Then, minority shareholders must turn in the remaining shares, and receive a compensation p_S per share from the Buyer. Squeeze-out procedures create additional, constant transaction costs C_S for the Buyer.

Courts enforce shareholder protection laws. We assume that minority shareholders may legally challenge the fairness of the cash compensation and move to court (which we designate '*price fairness procedures*' in the following).[22] In this case, court procedures last T periods, and shareholders discount future payments with the interest rate r. Eventually, the court decides in favor of the Buyer with probability $\lambda \in [0, 1]$. We assume the allocation of legal fees under the American rule, i.e. each party bears the same litigation costs L.[23] In order to evade court proceedings, the Buyer can make a take-it-or-leave-it settlement offer to litigating shareholders.

The noncooperative takeover game consists of four stages as displayed in Fig. 1: The bid by the Buyer (Stage 1), the tendering process (Stage 2), the squeeze-out decision (Stage 3) and shareholder litigation (Stage 4).

The game begins with the Buyer who decides at stage 1 whether to make an offer to shareholders in order to take over the target firm. If a bid is made, shareholders may either accept the offered price and tender their shares or holdout and potentially benefit from higher share prices if the takeover is successful. The game ends if the Buyer fails to collect enough shares to assume corporate control. If sufficient shares are tendered at stage 2, the takeover is successful and the Buyer may decide if he wants to squeeze-out the minority shareholders at stage 3. In case of a squeeze-out, the Buyer pays a compensation to the minority shareholders for collecting the remaining shares. Minority shareholders may accept this payout price, or move to court for price fairness procedures at stage 4. The court then decides the case in favor of the Buyer with the exogenous probability λ.

4.2. From court to takeover bids

In this sequential takeover game with complete information, the Buyer makes a profit-maximizing bid to take over the target. In the following, we describe the reasoning of the Buyer and shareholders throughout the game. The optimal bid is then determined via backward induction.[24] Thus, our analysis begins at stage 4.

At stage 4, the shareholder S_i considers the squeeze-out price p_S of the Buyer. A rational shareholder will legally challenge the 'fairness' of the offer and litigate only if the expected gains from court procedures π_S^{4L} are positive, $\pi_S^{4L} > 0$.[25] Note that such price fairness procedures generally do neither contest the squeeze-out itself nor stall the transfer of the offered squeeze-out price p_S to shareholder S_i. When entering litigation, only the fairness of the payout price is put under judicial scrutiny, which may lead to an additional payment to shareholders if the court regards the initial offer as too low. The shareholder pays the litigation costs L upfront. The shareholder's payoff from litigation π_S^{4L} can be defined as

$$\pi_S^{4L} = \frac{(1-\lambda)(\eta v_1 - p_S)}{(1+r)^T} - L \tag{1}$$

We stylize price fairness procedures as follows: if the court believes the shareholder to have a righteous claim, it will discard the squeeze-out price of the Buyer and enforce the 'fair' compensation, ηv_1. A potential court bias is common knowledge and captured by η. We assume that courts will generally attempt to determine the true post-takeover value v_1, and market participants expect an unbiased court ($\eta = 1$) to enforce a price that equals the true share value.[26] A pro-shareholder court ($\eta > 1$), however, is biased in its interpretation of 'fairness' and will enforce higher compensations. A pro-buyer court ($\eta < 1$) will be expected to stipulate lower payments. The shareholders win fairness procedures with probability $1 - \lambda$, and receive the present value of the difference between the court-determined 'fair' price and the offered price.

At stage 3, the Buyer decides whether to squeeze-out minority shareholders and, in that case, what price should be offered as compensation.

Concerning the offered price: the Buyer knows that shareholders have no incentive to litigate when the squeeze-out price p_S equals the expected net value of litigation to shareholders, i.e. their

[18] The general outcome of the game does not change, if shareholders are assumed to be risk-averse. In that case, shareholders will prefer an even lower, but certain payout price offered by the buyer to the risky outcome of litigation. In other words, shareholder risk-aversion relaxes the lower threshold for the optimal price offer.

[19] Transaction costs in this regard also include effort costs due to legal conflict with minority shareholders.

[20] It is commonly assumed that (some) higher concentration in control of a corporation can lead to a higher firm value, e.g., Shleifer and Vishny, 1986; Bolton and Von Thadden (1998). In this takeover model, we do not consider countervailing effects, such as reduced market capitalization and lower liquidity.

[21] This is a simplifying assumption. In many jurisdictions, it is sufficient to own fifty-one percent of the shares to assume control of the target, while a squeeze-out cannot be launched by the controlling shareholder with less than, e.g., ninety percent of the shares. As this likely affects the tendering decision of remaining shareholders, we analyze this broader case in the Annex A2.

[22] We use this broader term of '*price fairness*' to identify the general implications of judicial price review in our game. Croci et al. (2017) show empirically that contesting the fairness of the offered price often pays out for minority shareholders. The second group of legal remedies is the legal challenge of the squeeze-out itself ('*action of avoidance*') which we leave to section 4.4.

[23] We do not focus on fee-shifting in this paper. For the German case, § 15 SpruchG specifies the allocation of court fees for fairness procedures.

[24] Finite games of complete information are solved via backward induction, see Fudenberg and Tirole (1999), p. 72.

[25] We treat the less frequent '*action of avoidance*', where the shareholder contests the legitimacy of the squeeze-out, in section 4.4.

[26] This is not always the case. For example, in appraisal proceedings under Delaware law, the court determines the fair value "exclusive of any element of value arising from the accomplishment or expectation of the merger" (§ 262h DGCL), i.e. a value that represents the pre-bid price v_0.

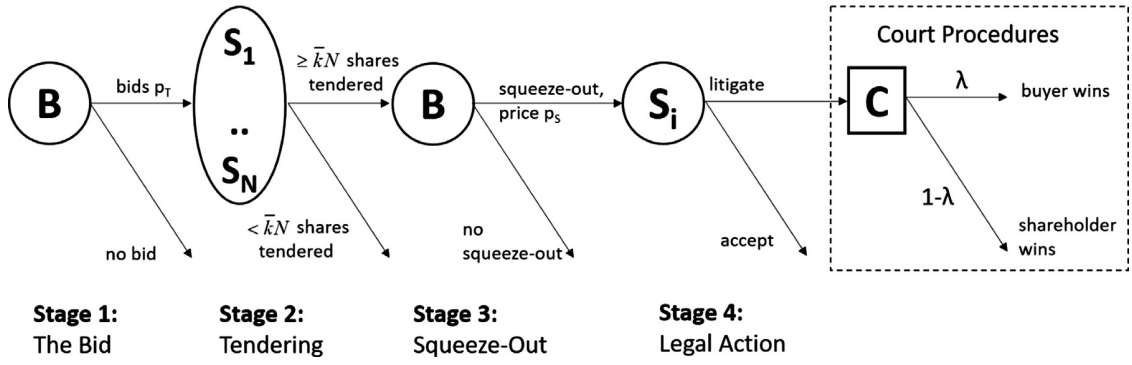

Fig. 1. Extensive form of the takeover game.

reservation price. In other words, the expected gains from litigation for shareholders then fall to $\pi_S^{4L} = 0$, and it does not pay off to contest the squeeze-out offer. Using (1), we thus find the minimum squeeze-out price to avoid litigation with

$$p_S \geq \eta v_1 - \frac{(1+r)^T L}{1-\lambda} = p_{MIN} \tag{2}$$

[27] Trivially, the squeeze-out price increases in the courts' evaluation of a 'fair' stock price. It is also straightforward that litigation costs L [28], expected case disposition time T, time preference of shareholders r, a pro-buyer bias ($\eta < 1$) of the court, and the probability of a success for the Buyer in court λ reduce the required minimum offer. Inequality (2) also shows that corporate Buyers can obtain a minimum offer below the post-takeover share value, $p_S < v_1$, if the litigation costs for shareholders are sufficiently high.[29]

Concerning the decision to launch the squeeze-out: The Buyer will choose a squeeze-out, if the value gained from complete control exceeds the additional buy-out costs of the Buyer, now holding $X \geq \bar{k}N$ shares after the tender offer. As shareholders will anticipate that only profitable squeeze-outs are executed by the Buyer, the squeeze-out can only serve as a credible threat to shareholders and thereby eliminate the free-riding problem (at stage 2), if and only if it is indeed in the interest of the Buyer at stage 3 to push for the squeeze-out once he learns that the takeover was successful. Thus, a credible squeeze-out[30] requires the condition $V_2 - v_1 X \geq (N-X)p_S + C_S$ to be fulfilled. Solved for p_S, the paid squeeze-out price that is profitable for the buyer cannot exceed p_{MAX} with

$$p_S \leq v_2 + \frac{(v_2 - v_1)X - C_S}{N-X} = p_{MAX} \tag{3}$$

Clearly, the upper threshold p_{MAX} decreases if procedural takeover costs C_S are high or if there is little or no added value of complete control ($v_2 \approx v_1$). Only if $p_{MAX} < p_{MIN}$, however, does it become too costly to buy out the remaining shareholders. Otherwise, the Buyer sets a credible and profit-maximizing squeeze-out price p_S with $p_S = p_{MIN} \leq p_{MAX}$ and litigation is avoided with certainty.

At stage 2, shareholders accept or reject the tender price offer p_T. In the following, we only focus on tender prices in the range $v_0 < p_T < v_1$. It is easy to see that lower tender prices will never succeed, and higher tender prices will typically lead to a successful but very costly takeover.[31] We call it a *free-rider-problem* in the tradition of Grossman and Hart (1980)[32], if each individual shareholder is better off holding out when takeover success is expected with certainty. In our model, the decision to tender is a (weakly) dominant strategy for shareholders if and only if the tender price is never below the expected squeeze-out price, $p_T \geq E(p_S)$,[33] and squeeze-outs are credible: if shareholders expect a successful takeover, holding out and rejecting the offer does not lead to an expected payment higher than p_T. If shareholders expect the takeover to fail, accepting the tender offer is always better than holding out and being stuck with v_0. Thus, squeeze-out procedures in our game allow a (weak) subgame-perfect Nash-equilibrium in pure strategies where all shareholders tender, and the takeover occurs with certainty.[34]

The free-rider-problem is restored, however, if the tender price is below the expected outcome of a squeeze-out, $p_T < E(p_S)$. Then, shareholders who expect a successful takeover are better off rejecting the offer and waiting for the squeeze-out payment (and possible court appraisal). In this case, there is no Nash-equilibrium in pure strategies. Equilibria in mixed strategies exist and takeovers still occur with positive probability (see corollary 2).

At stage 1, the Buyer decides whether to take over the target firm. If he decides to make a bid, he chooses the tender price that maximizes his expected payoff π_B. This payoff is defined by the value of complete control V_2 less total takeover costs, which are the sum of the expenses for buying shares and transaction costs for bidding and squeeze-out procedures. The Buyer will bid for the target if the following condition holds for his payoff at stage 1, π_B^1, with

$$\pi_B^1 = V_2 - Xp_T - (N-X)p_S - C_S - C_B > 0 \tag{4}$$

Given (4) holds, any price scheme with $p_T = E(p_S)$ achieves the takeover. Lower tender offers restore the free-rider-problem and create the risk of failure, and higher tender offers only increase

[27] Lower offers ($P_S < P_{MIN}$) fail to rule out costly shareholder litigation, even though the squeeze-out itself may be credible. We will show later that if shareholders can expect to increase profits from holding out (and litigating), then the free-riding problem reoccurs, and takeovers may not be successful at stage 2.

[28] The British fee-shifting rule ('the winner takes all') would increase the effective settlement payment by L.

[29] If the shareholder is risk-averse, an even lower offer P_S is sufficient as the shareholder prefers the certain payment to the uncertain gains from litigation.

[30] Credibility may not be an issue under a legal regime which requires a corporate buyer to announce any intended squeeze-out offer during the tender phase, and then the buyer is bound by law to this offer. However, this does not change the economic reasoning here, as a squeeze-out will only be considered if the buyer expects it to be profitable, thus $p_S \leq E(p_{MAX})$ holds.

[31] Note that costless '*price fairness*' procedures in pro-shareholder courts may increase the reservation price of shareholders above the post-takeover value.

[32] Burkart and Lee (2018) describe this behavior of shareholders as 'ex-ante'-free-riding in contrast to 'ex-post'-free-riding where shareholders do not actively take part in the governance of the firm.

[33] Gomes (2012) demonstrates that 'coercive' offers, i.e. offers where the squeeze-out price is below the tender offer price, are ineffectual because arbitrage traders can accumulate enough shares to prevent the buyer from reaching the squeeze-out threshold.

[34] Without squeeze-outs, only equilibria in mixed strategies exist, and takeover success is not certain.

takeover costs. While we assume that Buyer and shareholders form rational expectations, one might consider the impact of diverging party beliefs: if the Buyer or potential minority shareholders are more pessimistic about the prospect of winning in court than a rational decision-maker would be, then c.p. the optimal tender offer will be accepted and the takeover still succeeds. If at least one of the parties is overly optimistic about the outcome of trial, then c.p. some tender offers will be rejected, there will be litigation and takeovers fail with positive probability.

4.3. The optimal bid

We summarize:

Corollary 1. (i) Any tender offer that fulfils $p_T = p_S = p_{MIN} \leq p_{MAX}$ ensures a complete takeover with certainty. (ii) This tender price is the profit-maximizing offer from the Buyer to achieve the takeover with certainty.

In order to achieve a certain takeover of the target, the buyer chooses the price scheme$p_T = p_S = p_{MIN}$. Using (2) and (4), a takeover will be profitable if $V_2 - \left(\eta v_1 - \frac{(1+r)^T L}{1-\lambda}\right) N - C_S - C_B > 0$. We find that socially desirable takeovers will thus be executed under squeeze-out litigation if $V_2 + \frac{(1+r)^T N}{1-\lambda} L > \eta \cdot V_1 + C_S + C_B$ holds. Though this is not a necessary condition, it is straightforward that efficient takeovers are more likely to occur even under shareholder litigation if the private value of complete control over the target is high for the Buyer. In addition, sizeable costs of litigation, lengthy court procedures or lower transaction costs are disadvantageous for shareholders and allow the favorable takeover. Low litigation fees for shareholders and pro-shareholder courts, however, may turn some efficient takeovers not profitable for the buyer, and potentially produce an inefficiency.[35] Without an added value of complete control ($v_2 = v_1$), complete takeovers under low court fees will then be undesirable for the Buyer.

Buyers may increase their profits in a takeover if they are willing to accept potential failure in the tendering phase. For this, buyers choose a tender offer that is below the reservation price of shareholders, which reduces the buyer's expenses. However, this lower price is insufficient to eliminate the free-riding dilemma, and thus the takeover may fail with some probability. We call this the *gambling offer*. In this case, buyers tolerate the free-riding problem of shareholders in order to reduce takeover costs, and gamble that a lower bid, $p_T < p_S$, will still be successful. For an equilibrium in mixed strategies, all shareholders must be indifferent between tendering and holding out. We concentrate on the focal solution where all shareholders tender with probability t with $0 < t < 1$, and takeovers occur with probability $P(t)$. Thus, t must satisfy $(1 - P(t))(p_T - v_0) - P(t)(p_S - p_T) = 0$. Solved for P(t), takeovers occur with probability $P(t) = \frac{p_T - v_0}{p_S - v_0}$, and $0 < P(t) < 1$ holds for $p_T < p_S$. Any reduction of the tender offer p_T below the squeeze-out price p_S will thereby also reduce the probability of success. We thus have the following corollary:

Corollary 2. For any tender offer $p_T < p_S = p_{MIN} \leq p_{MAX}$, takeovers occur with a probability less than one.

So far, our results demonstrate that squeeze-out litigation (i.e. price fairness procedures) primarily induces some redistribution of social gains to shareholders, as intended by shareholder protection laws. From this perspective, the risk of litigation induces higher (tender) offers to avoid free-riding shareholders. This restricts the occurrence of some efficient takeovers, and thus potentially produces an allocative inefficiency. However, we find that squeeze-out litigation does not restore the free-riding problem per se (in contrast to Mueller and Panunzi, 2004, p. 25; Burkart and Lee, 2018, p. 20): Buyers may choose bids below the post-takeover value and successfully make tendering the (weakly) dominant strategy of shareholders. In other words, we demonstrate that the underlying incentive compatibility mechanism of squeeze-out procedures is not destroyed by litigation, and allows for certain success. The common observation that some takeovers actually fail can be well explained, however, as maximizing buyers are tempted to tolerate some free-riding in order to further increase profits. Given that the redistribution of takeover gains is not desirable to buyers, we would c.p. expect more gambling offers and a higher risk of failure when shareholder protection rights are expanded by legislators.

From an efficiency perspective, a more serious constraint to takeovers than litigation ("the legal risk") is the application of different thresholds for majority control and initiating squeeze-out procedures: if, for example, a raider may assume effective control of a corporation when he collects more than fifty percent of the shares, but squeeze-out laws require a ninety percent majority, the free-rider-problem manifests again.

Corollary 3. For two distinct legal thresholds for the ratio of acquired shares, k_1 (for takeovers) and k_2 (for squeeze-outs), with $k_2 > k_1$, any tender offer $p_T < v_1$ implies (i) that takeovers fail with a positive probability and (ii) that the risk of failure increases in the gap between k_1 and k_2.

In this two-threshold scenario, shareholders have an incentive to holdout if they believe that enough shares are tendered for the takeover to be successful but not enough for the squeeze-out, in line with prior results of Dalkir et al. (2018). As a consequence, there exists no equilibrium in pure strategies for any takeover offer that is below the post-takeover firm value, and efficient takeovers always occur with a probability smaller than one.[36] In other words, while the introduction of squeeze-out procedures helps to overcome the free-riding problem in takeovers, the use of two different thresholds at least partly restores it. The more restrictive the legislator is on the requirements for a squeeze-out, i.e. the more unlikely it is that the result of the tendering process meets these criteria, the lower is the desirable incentive effect of squeeze-outs on tendering shareholders in the mixed strategy equilibrium.

4.4. The action of avoidance

While we put the focus on the more widespread '*price fairness*'-litigation by shareholders, our approach also holds for '*action of avoidance*'-procedures, i.e. shareholders contest the legitimacy of the squeeze-out and seek its nullification. Overall, such '*action of avoidance*'-procedures rarely lead to a revocation of the squeeze-out (see, e.g., Aders et al., 2016; Croci et al., 2017), but induce similar settlement bargaining between the Buyer and litigating shareholders. As a major procedural difference, a shareholder who contests the squeeze-out itself is not entitled to the compensation payment while court proceedings are still ongoing. At stage 4, the litigating shareholder then expects the payoff $\pi_S^{4L} = \frac{\lambda p_S + (1-\lambda) v_1}{(1+r)^T} - L$. If the Buyer prevails in court, the offer p_S is enforced, otherwise the litigating shareholder keeps his share with its post-takeover value v_1. Applying backward induction, we again derive the minimum offer, which then gives $p_{MIN} = \frac{(1-\lambda)v_1 - (1+r)^T L}{(1+r)^T - \lambda}$. All others equal, this

[35] The buyer may still become the majority shareholder of the target, and thereby increase its efficiency. However, without squeeze-outs, the free-riding-problem unfolds and takeovers occur with a probability lower than one.

[36] Such restrictive squeeze-out laws are still preferable to laws which generally prohibit squeeze-outs. The case of separate thresholds for assuming control and initiating a squeeze-out is analyzed in the Annex A2.

payment is clearly lower than the minimum offer (2) under '*price fairness*' procedures. Thus, the '*action of avoidance*' can be considered less restrictive for Buyers. Supporting this theoretical insight, Croci et al. (2017) provide empirical evidence that the '*action of avoidance*' leads to significantly lower gains for shareholders than 'price fairness procedures'.

5. Application: judicial fairness review in Germany

In the following, we will use our takeover model to illustrate the economic reasoning behind a major turn in German jurisdiction on the judicial review of shareholder compensation.

5.1. German jurisdiction on shareholder compensation

In case of litigation, courts have to determine the fair compensation of shareholders without knowing the true firm value. Until 1999, German courts deemed it inappropriate to consider stock prices as a proxy for the fair market value of the firm. This view changed fundamentally in 1999 when the German Constitutional Court (see BVerfG 1 BvR 1613/94 [1999]) assessed this judicial practice to violate the constitutionally protected property rights of shareholders. Since then, appellate courts developed different approaches to use stock prices as proxy for fair compensation, ranging from the specific share price at the day of the general shareholder's assembly (see OLG Düsseldorf ZIP 2000, 1525 [2000]) to the average share price over a period of about 8 months (see OLG Stuttgart 4 W 15/98 [2000]). In 2001, the Federal Supreme Court eventually established two major principles, these were the close connection of the reference price by courts to the actual execution of squeeze-out procedures, typically taking the day of the general assembly's decision on the squeeze-out as reference date, and the calculation of the average share price over the preceding three-month period (see BGH II ZB 15/00 [2001]). This approach was meant to guarantee the connection to the actual transfer of ownership, but limit the effect of stock price volatility on the determined compensation.

In July 2010, the Federal Supreme Court changed its jurisdiction and ruled the three-month reference period to end already at the day of the announcement of squeeze-out procedures (see BGH II ZB 18/09 [2010]).

5.2. Stock prices as judicial proxy

Let the target be a listed firm. We apply the well-established *efficient market hypothesis* (see Samuelson, 1965; Fama, 1970; Rubinstein, 2001; Malkiel, 2005, and Yen and Lee, 2008) to describe the development of the target's share price at the stock market. Before the takeover at stage 1, the share price z equals the ex-ante firm value, $z^1 = v_0$. At stage 4, the share price equals the post-takeover value $z^{4,TO} = v_1$ if the takeover was successful, and $z^F = v_0$ in case of a failure. In between, we stylize the share price as a random variable with Z if the market believes in the success of the takeover, and specify $z = v_0$ otherwise. For simplicity, assume that there are only three realizations of the share price Z: it can be higher, lower or equal to the true post takeover value.[37] We specify that $Z = v_1$ occurs with probability $(1-\rho)$. The higher stock price $\bar{z}$, with $\bar{z} = v_1 + d$, and the lower stock price $\underline{z}$, with $\underline{z} = v_1 - d$, are equidistant from v_1 and are realized with symmetric probability $\frac{\rho}{2}$. Thus, d can be interpreted as the average deviation from the expectancy value, and $E(Z) = v_1$ applies. We assume that all this is known to the informed parties of the takeover, the Buyer and the target's shareholders. Only the court, as the external enforcement agency, does not know the true firm value, but observes the stock market price.

5.3. Shifting the reference period prior to the squeeze-out announcement

At first, imagine the reference period includes a certain amount of time after the public squeeze-out announcement, i.e. the time period between the public offer and the general assembly's decision. Then, the court will observe the realization of the share value after the squeeze-out price is set by the Buyer at stage 3.[38] Given the success of the takeover and the squeeze-out, the decision to litigate by minority shareholders is then also based on the observed realization of the stock price Z. For example, when the high stock price $\bar{z}$ is realized, then minority shareholders can expect to extract from court procedures $E\left(\pi_S^{4L}|\bar{z}\right) = p_S - L + \frac{(1-\lambda)(\eta(v_1+d)-p_S)}{(1+r)^T}$. In order to evade costly litigation and legal uncertainty, the Buyer should clearly offer $p_S \geq \pi_S^{4L}$ as before.

As the Buyer has to set the squeeze-out price before the realization of Z is observed, he is unable to rule out shareholder litigation without increasing the payout price p_S. More specifically, the previously minimum payout offer (2) will prove insufficient whenever $Z = \bar{z}$ is observed and lead to costly shareholder litigation with probability $\frac{\rho}{2}$. Any higher payout price increases takeover costs due to the increased payment. Any lower payout price increases takeover costs due to increased litigation. Furthermore, any payment that falls short of the high stock price, $p_S < \eta\bar{z} - \frac{(1+r)^T L}{1-\lambda}$ effectively restores the free-riding dilemma. Then, holding out and waiting for the realization of Z is preferable to tendering for shareholders if the takeover is deemed certain.

Consequently, a judicial routine that refers to the development of the stock price after the squeeze-out announcement of the Buyer incentivizes shareholders to wait for the realization of the stock price.[39] Such procedures increase c.p. the risk of a failed takeover or require higher payout offers from the Buyer. Marginal takeovers are potentially discouraged under this judicial regime. Note that the inefficiency is caused only by the information disadvantage of the first-mover, the Buyer, about the enforced stock price by courts.

Our findings suggest that the change in jurisdiction of the German Federal Court in 2010 corrected this inefficiency. In the words of the court, "the value, based on the three-month period before the general assembly, is neither known nor predictable at that time. It cannot be used to determine the payment offer for compensation [..]" (BGH II ZB 18/09, p.13 [2010]). The legal reasoning of the German Federal Court acknowledged the informational disadvantage of the first-moving buyer under the previous judicial practice, and thus changed its jurisdiction. By shifting the reference period prior to the squeeze-out announcement, both decision-makers, the Buyer and shareholders, have symmetric information about the potential reference price of the court when it comes to squeeze-out procedures.

6. Conclusion

An efficient legal system should encourage value-improving takeovers of firms. Against this background, we apply a sequential

[37] One could also assume the stock price to be normally distributed around the mean value v_1. Even though the results are qualitatively similar, this complicates the analysis. Thus, we apply the described simplification.

[38] This broadly reflects the earlier German jurisdiction of a reference period of three months before the day of the shareholder resolution that approves the squeeze-out (see above).

[39] Note that we derive this finding under the assumption of efficient financial markets. The incentive to holdout may be even higher if shareholders engage in strategic trading to further increase the stock price.

takeover game with a corporate buyer and atomistic shareholders of a target firm to analyze the potential conflict between the incentive mechanism of squeeze-outs in public takeover bids and shareholder litigation.

We show that in theory, despite the risk of litigation, the buyer is able to achieve the complete takeover of the target and acquire some part of the takeover gains. For this, a rational buyer has to anticipate the expected value of litigation to minority shareholders from the beginning, and then make a tender offer that is below the post-takeover stock value but equal to the reservation price of shareholders. While a judicial price fairness review clearly increases this price offer above the pre-takeover stock value, thus making the takeover costlier to the buyer, it does not restore the free-riding problem: an equilibrium in pure strategies exists where the buyer offers the expected outcome of litigation to shareholders, and all shareholders tender. In other words, the risk of shareholder litigation requires a higher (minimum) offer from the buyer to incentivize tendering and thus avoid the free-riding problem. Lengthy court procedures and a high time preference of shareholders work in favor of the buyer and lower this minimum offer, while pro-shareholder courts imply a higher price offer and thus higher takeover costs. This implication generally holds for the two standard legal remedies of shareholders, the '*action of avoidance*' and '*price fairness*' review, though the former shows a lower impact on the buyer's minimum offer.

Even though shareholder litigation does not contradict the incentive compatibility mechanism of squeeze-outs, several considerations may explain the common observation of litigation and takeover failure.

First, the existence of relevant litigation costs to shareholders enables buyers to limit the costly increase in takeover premiums in order to incentivize tendering. Given the potential costs of litigation and the risk of losing in court, shareholders will be willing to accept some reduction in the offered payout price. Particularly in pro-shareholder courts, buyers can only succeed at paying below post-takeover stock prices when litigation costs are sizeable. Any mechanism that reduces litigation costs for shareholders, such as class action procedures, thus implies a higher tender offer from the buyer to keep shareholders from free-riding. As a consequence, some buyers might find it preferable to tolerate this free-riding behavior, accept a positive risk of failure, and keep the tender offer low. In this regard, rational buyers gamble as they trade the increased risk of failure against the lower takeover costs in the tendering phase.

Second, the existence of two different legal thresholds for corporate control and the feasibility of squeeze-out procedures effectively restores the free-riding dilemma. Whereas a similar result by Gomes (2012) relies on the assumption of increased bargaining power of arbitrageurs, we show in a model with atomistic, hence powerless shareholders that the free-riding problem is caused simply by the mere existence of two different legal thresholds. In this case, shareholders may speculate that the takeover succeeds without meeting the higher threshold of the squeeze-out which would make holding out the dominant strategy. Consequently, the more rigid the threshold for squeeze-outs is, the stronger the free-riding problem resurfaces. As the use of two distinct thresholds is particularly widespread in European takeover laws, this creates a major inefficiency in squeeze-out procedures. Lawmakers should consider applying a one-threshold approach. The recently increased use of tender offers with subsequent squeeze-outs after the removal of such a second, supermajority threshold for takeovers under US Delaware law clearly supports this finding.

Third, an additional limitation lies in the judicial evaluation of the firm value. Such an evaluation often uses stock prices as a reference for the fair value, but significant fluctuations during takeovers create uncertainty to buyers. Exemplified by the change in jurisdiction of the German Federal Court, it appears reasonable that courts apply a reference period of the firm's stock price that ends prior to the announcement of the squeeze-out decision. Otherwise, the buyer has an informational disadvantage when defining the payout price and this would cause either higher takeover costs or a higher probability of failure.

Appendix A.

Proof of Corollary 1

(i) A takeover with certainty requires that there is no free-riding problem. First, a price $p \leq p_{MAX}$ ensures that the squeeze-out is credible. Second, the price $p = p_{MN}$ is the lowest price that rules out litigation. Any lower price will incentivize shareholders to holdout and legally challenge the 'fairness' of the payment, which puts the takeover at risk. Third, any price p_T that fulfills $p_T \geq E(P_S)$ makes tendering at least as preferable for shareholders as holding out.

(ii) Consider an alternative price scheme $[p_T = p_s + \Delta p;\ p_s \leq p_{MAX}]$ with $\Delta p > 0$. Again, this price set achieves a certain takeover. However, incentive compatibility only requires the condition $P_T \geq P_S$ to be binding. Thus, takeover costs are higher by ΔpX. For any $\Delta p < 0$, tendering is no more a dominant shareholder strategy and takeovers fail with positive probability.

Proof of Corollary 3

Assume two legal thresholds, k_1 and k_2: the threshold k_1 defines the ratio of shares required for obtaining majority control of a firm. Threshold k_2 defines the required ratio of shares for starting squeeze-out procedures, with $k_2 > k_1$. For simplicity, the Buyer makes the offer $P_T = P_S$. There is no equilibrium in pure strategies: Given that a shareholder expects $k_2 > k > k_1$, that is, the takeover is successful but a squeeze-out is not possible, it is best not to tender. For expectations of $k < k_1$, tender is preferable as the takeover is expected to fail. For $k > k_2$, the decision to tender is irrelevant for shareholder payoffs. For an equilibrium in mixed strategies, shareholders must be indifferent between tendering and holding out. We concentrate on the focal solution and assume that all shareholders tender with probability t. Let $F(x, y, z)$ be the Binomial distribution function with x trials, probability of success y, and no more of z trials to be successful, then the probability of a successful takeover is determined by $P_1(t) = 1 - F(N, t, k_1N - 1) = \sum_{j=k_1N}^{N} \frac{N!}{j!(N-j)!} t^j (1-t)^{N-j}$. Trivially $P_2(t) = 1 - F(N,t,k_2N - 1) < P_1(t)$ holds, which implies that a takeover is strictly more likely than a takeover with a subsequent squeeze-out. Shareholders are indifferent if the gains of tendering equal the loss of tendering, $(1 - P_1(t))(p_t - v_0) - (P_1(t) - P_2(t))(v_1 - P_T) = 0$. Solving for the probability of a takeover, we find $P_1(t) = \frac{p_T - v_0 + P_2(t)(v_1 - p_T)}{v_1 - v_0} < 1$. We know that $P_1(t)$ and $P_2(t)$ increase monotonically in the interval (0,1). This implies that the existence of squeeze-out procedures increases the probability of a takeover for any $P_2 > 0$. However, the higher c.p. the legal threshold for squeeze-out procedures, k_2, the lower P_2 and the lower the positive impact on the probability of successful takeovers. Note that this result equals the solution of BEBCHUCK (1989, p. 175) for the case $P_2 = 0$. If $k_1 = k_2$, then $P_1 = P_2$. Thus, tendering is the dominant strategy and takeovers are always successful, $P(t) = 1$. Also, for the case $P_T = v_1$, no free-riding problem exists and takeovers occur with certainty.

Declaration of Competing Interest

The authors report no declarations of interest.

References

Aders, Christian, Kaltenbrunner, Hannes, Schwetzler, Bernhard, 2016. Die Kosten des "Private Taking in Deutschland": Eine empirische Untersuchung. Corporate Finance, 9., pp. 295–306.

Allen, Overy, Accessed March 12, 2019 2017. A Guide to Public Takeovers in Germany. www.allenovery.com.

Amihud, Yakov, Kahan, Marcel, Sundaram, Rangarajan K., NYU Working Paper No. FIN-02-009 2003. The Foundations of Freezeout Laws in Takeovers. https://ssrn.com/abstract=1294176.

Bagnoli, Mark, Lipman, Barton L., 1988. Successful takeovers without exclusion. Rev. Finance Stud. 1 (1), 89–110.

Bebchuk, Lucian A., 1989. Takeover bids below the expected value of minority shares. J. Finance Quant. Anal. 24, 171–184.

Bolton, Patrick, Von Thadden, Ernst-Ludwig, 1998. Blocks, liquidity, and corporate control. J. Finance 53, 1–25.

Boone, Audra, Broughman, Brian, Macias, Antonio J., 2018. Shareholder approval thresholds in acquisitions: evidence from tender offers. J. Corp. Finance 53, 225–245 (C).

Burkart, Mike, Lee, Samuel, 2018. Activism and Takeovers. European Corporate Governance Institute, Brussels, Working Paper No. 543/2018.

Burkart, Mike, Panunzi, Fausto, 2003. Mandatory Bids, Squeeze-Out, Sell-Out and the Dynamics of the Tender Offer Process. European Corporate Governance Institute, Brussels, Working Paper No. 10/2003.

Burkart, Mike, Gromb, Denis, Panunzi, Fausto, 1998. Why higher takeover premia protect minority shareholders. J. Polit. Econ. 106 (1), 172–204.

Cain, Matthew D., Solomon, Steven D., Ohio State Public Law Working Paper No. 236 2014. Takeover Litigation in 2013.

Cornelli, Francesca, Li, David D., 2002. Risk arbitrage in takeovers. Rev. Finance Stud. 15 (3), 837–868.

Croci, Ettore, Nowak, Eric, Ehrhardt, Olaf, 2017. The corporate governance endgame – minority squeeze-out regulation and post-deal litigation in Germany. Manage. Finance 43, 95–123.

Dalkir, Elif, Dalkir, Mehmet S., Levit, Doron, 2018. Freeze-out mergers. Rev. Finance Stud. (Forthcoming) https://ssrn.com/abstract=3188109.

Faccio, Mara, Lang, Larry H.P., 2002. The ultimate ownership of Western European corporations. J. Finance Econ. 65 (3), 365–395.

Fama, Eugene F., 1970. Efficient capital markets: a review of theory and empirical work. J. Finance 25, 383–417.

Fudenberg, Drew, Tirole, Jean, 1999. Game Theory. MIT Press, Cambridge.

Gehling, Christian, Heldt, Cordula, Royé, Claudia, Accessed March 18, 2019 2007. Squeeze-out - Recht und Praxis. Studien des Deutschen Aktieninstituts 39. www.dai.de/files/dai_usercontent/dokumente/studien/2007-10-01%20Squeeze%20Out.pdf.

Gomes, Armando, 2012. Takeovers, Freezeouts, and Risk Arbitrage, Working Paper on 02/25/2019 http://apps.olin.wustl.edu/faculty/gomes/takeovers.pdf.

Grossman, Sanford, Hart, Oliver, 1980. Takeover bids, the free-rider problem, and the theory of the corporation. Bell. J. Econ. 11, 42–64.

Hirshleifer, David, Titman, Sheridan, 1990. Share tendering strategies and the success of hostile takeover bids. J. Polit. Econ. 2 (98), 295–324.

Holmström, Bengt, Nalebuff, Barry, 1992. To the raider goes the surplus? A reexamination of the free-rider problem. J. Econ. Manag. Strategy 1, 37–62.

Kaisanlahti, Timo, 2007. When is a tender price fair in a squeeze-out? Eur. Bus. Organ. Law Rev. 8 (4), 497–519.

Krebs, Christian A., 2012. Freeze-out transactions in Germany and the U.S.: a comparative analysis. German Law J. 13 (8), 941–978.

Krishnan, C.N.V., Masulis, Ronald W., Thomas, Randal S., Thompson, Robert B., 2012. Shareholder litigation in mergers and acquisitions. J. Corp. Finance 18, 1248–1268.

Kyle, Albert S., Vila, Jean-Luc, 1991. Noise trading and takeovers. Rand J. Econ. 22 (1), 54–71.

Malkiel, Burton G., 2005. Reflections on the efficient market hypothesis: 30 years later. Finance Rev. 40 (1), 1–9.

Martynova, Marina, Renneboog, Luc, ECGI - Finance Working Paper No. 114/2006; CentER Discussion Paper Series No. 2006-06 2006. Mergers and Acquisitions in Europe. https://ssrn.com/abstract=880379.

Mueller, Holger M., Panunzi, Fausto, 2004. Tender offers and leverage. Q. J. Econ. 119 (4), 1217–1248.

Offenberg, David, Pirinsky, Christo A., 2015. How do acquirers choose between mergers and tender offers? J. Finance Econ. 116 (2), 331–348.

Porta, Rafael La, Lopez De Silanes, Florencio, Shleifer, Andrei, Vishny, Robert W., 1998. Law and finance. J. Polit. Econ. 106 (6), 1113–1155.

Restrepo, Fernan, Subramanian, Guhan, 5 Harvard Business Library Review 205. Accessed March 18, 2019 2015. The Effect of Delaware Doctrine on Freezeout Structure and Outcomes: Evidence on the Unified Approach. http://nrs.harvard.edu/urn-3:HUL.InstRepos:17742178.

Rubin, Amir, 2007. Ownership level, ownership concentration and liquidity. J. Financ. Mark. 10, 219–248.

Rubinstein, Mark, 2001. Rational markets: yes or no? The affirmative case. Finance Anal. J. 57 (3), 15–29.

Samuelson, Paul A., 1965. Proof that properly anticipated prices fluctuate randomly. Ind. Manage. Rev. 6, 41–49.

Scherer, Frederic, 1988. Corporate takeovers: the efficiency arguments. J. Econ. Perspect. 2, 69–82.

Shleifer, Andrei, Vishny, Robert W., 1986. Large shareholders and corporate control. J. Polit. Econ. 94 (3), 461–488.

Subramanian, Guhan, 2005. Fixing freezeouts. Yale Law J. 115 (1), 2–70.

Ventoruzzo, Marco, 2010. Freeze-outs: transcontinental analysis and reform proposals. Virginia J. Int. Law 50 (4), 841–917.

Yarrow, George K., 1985. Shareholder protection, compulsory acquisition and the efficiency of the takeover process. J. Ind. Econ. 34 (1), 3–16.

Yen, Gili, Lee, Cheng-Few, 2008. Efficient market hypothesis (EMH): past, present and future. Rev. Pacific Basin Finance Mark. Policies 11 (2), 305–329.

4. Prosecution and Conviction under Hindsight Biased Information Updating in Adversary Legal Systems.

(Journal of Institutional and Theoretical Economics 177: 404-427)

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JITE

Journal of Institutional and Theoretical Economics

JITE

Vol. 177, No. 4 Dezember 2021

Mohr Siebeck

JITE Journal of Institutional and Theoretical Economics Vol. 177, No. 4, Dezember 2021

Journal of Institutional and Theoretical Economics

Citation method: JITE

Editors: Prof. Dr. Gerd Muehlheuser, Department of Economics, University of Hamburg, Von-Melle-Park 5, 20146 Hamburg, Germany "v.i.S.d.P"; Prof. Dr. Ralph-Christopher Bayer, The University of Adelaide, School of Economics, Australia
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Articles are refereed by specialists.
There is no submission fee.

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Please also follow the Instructions for Autors on the inside back cover.

Frequency of publication: JITE is published in quarterly issues of approximately 750 pages per year.

Subscriptions: Information on subscriptions can be found at www.mohrsiebeck.com/jite under "Subscriptions". For questions on a subscription, please contact us at journals@mohrsiebeck.com

Online access: Both private and institutional subscriptions include free access to the entire text on our website. Further information about registration and special requirements for institutional users can be found at www.mohrsiebeck.com/en/electronic-products

Publisher: Mohr Siebeck GmbH & Co. KG, Postfach 2040, 72010 Tübingen, www.mohrsiebeck.com, info@mohrsiebeck.com

Advertising service: Tilman Gaebler, P.0. Box 113, 72403 Bisingen, tilman.gaebler@t-online.de.
V.i.S.d.P.: Ursula Schwenzer, Mohr Siebeck (schwenzer@mohrsiebeck.com).

Typeset by Da-TeX, Leipzig. Printed by Gulde Druck, Tübingen, on non-aging paper.

ISSN 0932-4569 (print-edition) eISSN 1614-0559 (online-edition)

Printed in Germany.

Prosecution and Conviction under Hindsight-Biased Information Updating in Adversary Legal Systems

by

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Received May 13, 2020; in revised form March 28, 2021;
accepted May 25, 2021

The traditional literature on plea bargaining relies on prosecutors who are perfect Bayesian decision-makers, and on courts that can eventually verify the true guilt of the defendant. In this paper, we introduce a limitedly rational prosecutor who is biased in hindsight when evaluating new information. We find that the influence of this behavioral bias on the established equilibria in the literature largely depends on what kind of information causes the bias. Biased evaluation of incriminating evidence may induce higher self-selection at the cost of more wrongful convictions. A biased interpretation of observed deal rejections may eliminate the semiseparating equilibrium.

Keywords: criminal procedure, plea bargaining, limited rationality, Bayesian learning

JEL classification code: D83, D91, K14, K41

1 Introduction

Prosecutors are meant to solve crime and bring criminals to trial. A common element of criminal procedure, however, is the plea bargain between the prosecutor and the defendant in which the latter pleads guilty to a reduced charge, and court procedures are avoided. Such pretrial agreements are negotiated in the shadow of the court's jurisdiction, save resources, and eliminate the risk inherent in any trial.

* Leibniz School of Business, Hanover, Germany. I am thankful for comments and suggestions made by participants during the German law-and-economics conference in Ljubljana, the European law-and-economics conference in Milan, the Spanish law-and-economics conference in Lleida, the workshop on the economics of litigation in Hamburg, the Hamburg lectures in law and economics, the faculty meetings in Hanover and Magdeburg, and the annual workshop of the board for institutional economics of the German economic society in Potsdam.

Journal of Institutional and Theoretical Economics 177, 404–427 – ISSN 0932-4569
DOI: 10.1628/jite-2021-0017 – © 2021 Mohr Siebeck

A major feature of plea bargaining is the revelation of hidden information. Even though the prosecutor does not know the actual guilt of a suspect, guilty and innocent defendants may show different reactions to a given plea offer. Thus, the plea-bargaining mechanism can induce at least a partial separation between the guilty and the innocent. In a game-theoretic approach, Baker and Mezzetti (2001) (henceforth, the BM model) find such a semiseparating equilibrium: some guilty defendants reveal themselves and accept the plea bargain, while the remaining guilty and all innocent defendants reject it and move to trial. In the world of this model, it is the credible threat of the prosecutor to have the actual guilt verified by the court that drives the self-selection process. As such bargained deals save court resources, the high rate of plea deals in criminal procedures, particularly in the U.S., appears socially favorable (see, e.g., Covey, 2009; Kim, 2010).

We think the traditional argument is unsatisfactory in two ways. First, it relies on the assumption of an exogenous court system that is eventually capable of verifying the defendant's true type with positive probability (see Baker and Mezzetti, 2001, p. 154). This implies that, when bargaining the deal with the defendant, the prosecutor can rely on the court to serve as an "automatic verifier of last resort" if bargaining fails. It appears questionable, however, to assume that the accuracy of the court system is not affected by such plea deals. Particularly for adversarial legal systems, it is the performance of the prosecutor and the defendant's attorney that determines the outcome of the litigation contest (see Tullock, 1975). As a higher self-selection of guilty defendants leaves only the more uncertain cases to be brought to trial, a rational prosecutor should become less confident once in court. But what drives his effort to convict the defendant in court when in a mixed-strategy equilibrium (as in the BM model), the prosecutor is made indifferent between charging the defendant and dropping the case?

Second, the obtained semiseparating equilibrium in the BM model is based on the concept of a Bayesian prosecutor who correctly updates his beliefs when observing new information. There has been a traditional debate among law-and-economics scholars whether enforcement agents should be regarded as truly Bayesian decision-makers (see Shavell, 1996, 1995; Schwartz, 1995). But how does the socially favorable semiseparating equilibrium change when the prosecutor is actually limitedly rational, thus not perfectly Bayesian?

Following the growing literature on limited rationality, we consider prosecutors that tend to be biased when evaluating criminal cases in hindsight. According to Wasserman, Lempert, and Hastie (1991, p. 30), hindsight bias is "a projection of new knowledge into the past accompanied by a denial that the outcome information has influenced judgments." As a consequence, hindsight-biased agents tend to believe more strongly in what they observe than a rational decision-maker would do (see, e.g., Fischhoff, 1975, p. 288). For criminal procedure, this bias then may inflate or degrade the confidence and bargaining power of prosecutors under uncertainty. In contrast to the traditional literature, the welfare effects of plea bargaining under hindsight bias become more ambiguous, and some previously established equilibria may no longer exist.

It is the aim of this paper to study the self-selection mechanism of plea bargaining when prosecutors are not perfect Bayesian decision-makers. We extend the BM framework model by introducing the adversarial nature of courts through a litigation tournament. Moreover, prosecutors are biased in hindsight when observing the rejection of plea deals and when examining new evidence in the case. We show that the influence of hindsight bias on equilibrium depends on what kind of information caused the biased Bayesian updating. In this regard, we provide the first formal analysis of prosecution under hindsight bias, and derive implications for the efficiency of plea bargaining and legal policy.

The paper is organized as follows: Section 2 reviews the related literature. In section 3, the basic framework of the prosecution game is introduced. Section 4 analyzes the prosecution game when adversarial litigation is seen as a contest. Section 5 presents our concept of hindsight bias and shows how the equilibria of the BM model are affected. Section 6 discusses the main contribution for legal policy, and section 7 concludes.

2 Related Literature

A major strand of the law-and-economics literature on the plea-bargaining mechanism has studied its use as a screening device to distinguish between guilty and innocent defendants (see, e.g., Grossman and Katz, 1983; Reinganum, 1988; Kobayashi and Lott, 1996). In this perspective, the prosecutor's plea offer could induce an efficiency-enhancing self-selection process where the guilty defendants accept the bargain and the innocent defendants reject it.

This basic screening model was particularly challenged by Baker and Mezzetti (2001). The authors pointed out that the threat of the prosecutor to move to court whenever bargaining fails is not credible, as in equilibrium only innocent defendants were expected to reject the plea offer. Given exogenous verification in court, the authors demonstrated that plea bargaining still induces a desirable semiseparating solution where some guilty defendants accept the bargain and all remaining defendants reject it. Since then, some scholars have addressed this commitment problem more closely. Kim (2010) finds that the semiseparating equilibrium does not rely on credible prosecutorial investigations ex post, but requires only exogenous verification by courts. Franzoni (1999) concludes that endogenous investigative effort by the prosecutor leads to a dilution of deterrence through plea bargaining, which increases the level of crime. A similar solution is also obtained for endogenous jury decisions by Bjerk (2007), who finds lower equilibrium sanctions. Moreover, Bar-Gill and Ben-Shahar (2009) indicate that even though, given his budget constraint, the prosecutor can never credibly commit to charge all defendants, the collective refusal of the defendants resembles a public-good game, and fails.

Further challenges to the screening model have emerged from the field of psychology and behavioral economics. While the basic theory requires a perfectly ra-

tional economic agent who correctly interprets observed behavior, empirical and experimental research has revealed several constraints on human decision-making, and has developed alternative concepts of limited rationality to capture these effects.[1] Concerning the plea-bargaining mechanism, several authors suggest distinct biases that may distort the behavior of the prosecutor, such as overconfidence, denial, discounting of future costs, and the sunk-cost fallacy. According to Bibas (2004), the framing of the plea-bargaining situation leads to diverging behavior: the gain-framed prosecutor will be less risk-taking and less aggressive than the loss-framed defendant. Furthermore, the author speculates about a relevant anchoring effect of the initial plea offer, as the initial offer typically serves as a reference for the subsequent negotiations. Burke (2007) acknowledges that selective information can amplify an a priori opinion, thus inflating the prosecutor's beliefs about the strength of the case.

Interestingly, researchers show a remarkable consensus that hindsight bias[2] in particular poses a substantial problem in the correct interpretation of evidence by the prosecutor (see, among others, Bibas, 2004; Burke, 2007; Garoupa, 2012). Experimental evidence on a bias in hindsight dates back to Fischhoff (1975) and Fischhoff and Beyth (1975), who were the first to demonstrate that ex post reports influenced how likely people believed an event would take place ex ante. Since then, hundreds of studies inside and outside the lab have confirmed the occurrence of flawed memory, unjustified confidence, and exaggerated performance evaluation by a third party when agents act under uncertainty and observe ex post information (among others, see Christensen-Szalanski and Willham, 1991; Glaser, Langer, and Weber, 2005; Studdert et al., 2005). For criminal procedure, the occurrence of hindsight bias can have different effects: (i) The prosecutor may subconsciously adjust his ex ante belief and doubts about the defendant's guilt to fit the observed evidence ("memory distortion"). (ii) When losing or winning a trial, the prosecutor may falsely believe ex post that he anticipated this outcome all along, and is surprised that others did not ("knew-it-all-along effect"). (iii) When evaluating the defendant's guilt, the prosecutor has the advantage of knowing the outcome and all consequences of the defendant's action with certainty, while the defendant did not when committing the criminal act ("outcome effect").

Frequent studies also analyze the nexus between hindsight bias and learning from experience. Biais and Weber (2009) show that hindsight-biased traders in financial markets will underestimate volatility, which results in inefficient port-

[1] For example, behavioral economists studied the use of different heuristics and the resulting biases. A more realistic model of human decision-making was proposed by prospect theory (see, e.g., Kahneman and Tversky, 1984).

[2] Hindsight bias is to be distinguished from other behavioral biases, even though some symptoms appear similar. *Overconfidence* implies that an agent believes himself more capable than the average individual. *Confirmation bias* describes the unconscious selection of information in a way that is always in line with the agent's ex ante beliefs. *Hindsight bias* distorts the memory of the agent's ex ante beliefs in a way to be in line with the observed outcome.

folio choices. Less biased traders show better investment performance and are more likely to be the top earners among their peers. Madarász (2012) studies information projection where a person misperceives the distribution of information, i.e., to what degree their information is shared with others. In that case, agents overly attribute observed divergent outcomes to differences in the other person's characteristics, and tend to underestimate uncertainty.

Previous research has so far established crucial determinants for the efficiency of the plea-bargaining mechanism. It is the scope of this paper to study prosecutor behavior when adversarial courts are described as a litigation contest, and to provide a first formal analysis of the effects of limited rationality, exemplified by the hindsight bias, on the efficiency of plea bargaining.

3 Model

In the following, we extend the framework exemplified by Baker and Mezzetti (2001). In our model, the probability of a correct court decision is determined through a litigation contest, and (rational) agents cannot rely on the court to serve as an "automatic verifier of last resort." Hence, we drop the BM assumption of an exogenous court system to verify the defendant's true type at the end of the game with positive probability (see Baker and Mezzetti, 2001, p. 154).

Consider the legal process as a game with two players, the prosecutor (P) and the defendant (D). The defendant can be either guilty of a crime, G, or innocent, I. The type of the defendant is exogenously specified by nature (N) at the beginning of the game, and only the defendant knows his true type. The ex ante probability of a guilty defendant is denoted by ϕ, and is common knowledge. The level of ϕ can be interpreted as the capability of the police force to present guilty suspects to the prosecutorial office. Information asymmetry exists in that the prosecutor does not know for certain the true type of the defendant. Thus, the prosecutor has to form (rational) beliefs about the defendant's type throughout the game. All other information is common knowledge.

The defendant is accused of committing the crime X, with X representing the harm to society. Given a conviction, the defendant receives a utility of $-X$ from a homogeneous sanction, and zero otherwise. The convicted defendant's disutility can be interpreted as prison time or a monetary penalty.

The prosecutor maximizes his expected-utility function, based on his beliefs. He receives a utility of X if the guilty defendant is convicted and a utility of $-bX$, with $b > 0$, if an innocent defendant is sentenced. The prosecutor receives a utility of zero if the innocent defendant is set free, but a utility of $-dX$, with $d > 0$, if a guilty defendant is wrongly released. Consequently, the prosecutor (and society) is interested in punishing criminals and setting free innocent individuals. The variable b captures the relative severity of wrongful convictions, and the variable d describes

the relative effect of wrongful acquittals.[3] Furthermore, the prosecutor receives a utility of $-cX$, with $1 > c > 0$, if he loses a case in court. This disutility can be interpreted as the damage to the prosecutor's reputation whenever he loses a case he decided to bring to court. The reputational loss is contingent on the severity of the crime, as we believe the prosecutor's reputation is more affected by the outcome of a severe case, such as murder or rape, than by minor offenses.[4] Both players are assumed to be risk-neutral and to maximize their expected utility.

In order to capture major institutional features of adversary legal systems, we assert that the prosecutor has complete bargaining power.[5] Thus, the prosecutor can make a take-it-or-leave it plea offer q with $q \geq 0$ to the defendant. Furthermore, as the court has no inquisitorial authority and cannot generate evidence on its own, we stylize litigation in adversary courts in the tradition of Tullock (1975) as rent-seeking games. In other words, litigation resembles a "*trial by battle*" (Tullock, 1975, p. 746, emphasis added), and the probability of winning in court is determined by the relative efforts of the litigants. At the last stage of the game, we thus apply a sequential litigation contest where the prosecutor acts as a first-mover. We believe that this is more appropriate for capturing the nature of criminal procedures where the prosecutor brings the charge and the defendant responds to these allegations.[6] This approach allows us to clarify the nature of the adversarial legal doctrine in our model, even though most adversarial legal systems show some inquisitorial elements, such as the (limited) discretion of the judge to discard evidence, reject motions, or advise during an interrogation.

The noncooperative prosecution game consists of four stages as displayed in the figure: the plea offer by the prosecutor (stage I), the reaction to the plea offer by the defendant (stage II), the prosecutor's decision to charge (stage III), and the litigation contest in court (stage IV). The outcomes U_P, U_g, and U_i represent the utility of the prosecutor, the guilty defendant, and the innocent defendant, respectively, at the end of the game.

At the beginning of the game, nature (N) chooses the defendant's type, which is either guilty or innocent. At stage I, the prosecutor then offers a plea bargain q to the defendant, not knowing his true type. The defendant then can either accept the bargain, which ends the game at stage II, or reject it. If the plea offer is rejected, the game continues. The following investigations of the prosecutor then produce an exogenous evidence signal s, which may reveal the innocence of the defendant (signal $\underline{s}$) with positive probability. At stage III, the prosecutor observes the rejec-

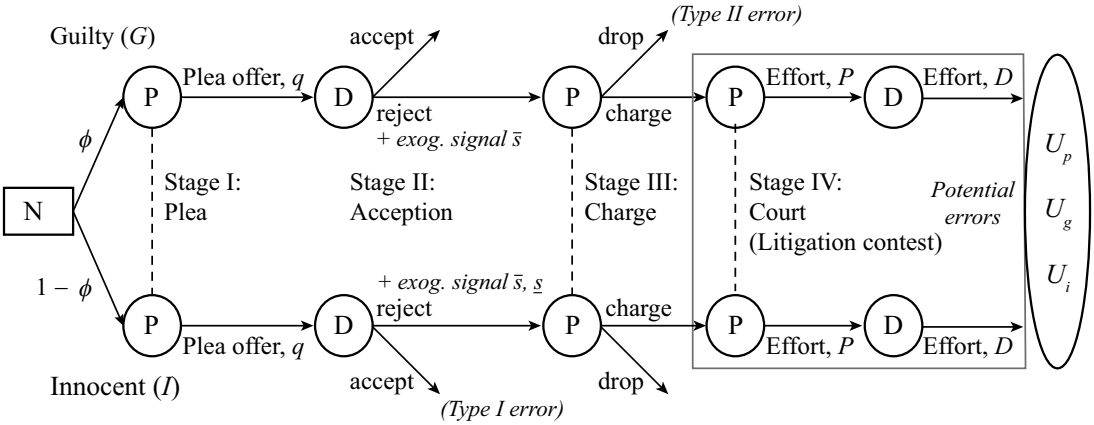
[3] In Franzoni (1999, p. 514), erroneous convictions are excluded by assumption. This effectively rules out the major obstacle to the prosecutor's performance in court.

[4] In the BM model, the authors propose a constant reputational cost for the prosecutor when losing in trial. We believe this to be unrealistic, as the severity of the crime greatly affects the public interest in a given case and thus puts pressure on the prosecution department.

[5] In adversary systems, prosecutors traditionally enjoy full discretion over the charge. Furthermore, they are clearly the repeat players in criminal procedure.

[6] Although we think the sequential contest is more convincing here, our results are qualitatively unchanged for a simultaneous contest.

Figure
Sequential Prosecution Game with Litigation Contest



tion of the plea offer and the evidence signal, and decides whether to bring the case to court. If the case is dropped, the game ends. If the prosecutor charges, both players enter the litigation contest (stage IV). Then the prosecutor as first-mover can exert effort to convince the judge of the defendant's guilt. The defendant then responds to the accusations and exerts effort as second-mover in the litigation subgame to demonstrate his innocence. The relative efforts of the litigants then specify the probability of success in court, and determine the respective outcomes U_P, U_g, and U_i.

4 Plea Bargaining with Litigation Contest

In this section, we present the implications for the BM framework when we apply the litigation contest to verify the defendant's true type at the end of the game. The prosecutor's strategy consists of a plea-bargain offer q, the decision to go to trial when observing a rejection of the plea offer and the evidence signal s, and the litigation effort in court. The defendant's strategy, depending on his type, consists of his reaction to a plea offer, and his effort in court.

4.1 The Stages of the Game

4.1.1 Stage IV: The Court

The adversary court system is modeled as a Tullock (1975) rent-seeking game. Both litigants, the prosecutor and the defendant, may exert costly effort to increase their probability of winning the case. We designate the continuous litigant efforts for the prosecutor and defendant as P and D, and specify $P, D \geq 1$. Thus, the probability of winning the case for the prosecutor can be described by $P/(P+D)$, and the probability for the defendant by $D/(P+D)$. That is, we assume the probability of prevailing in an adversarial court for a litigant to be determined only by

the litigant's effort relative to total effort.[7] For simplicity, marginal effort costs are constant, equal, and set to one. This also implies, because $P, D \geq 1$, that each party de facto faces a fixed litigation cost when entering the court.

The analysis requires a case separation: (i) the standard case – both parties actively seek to win in court ($P, D > 1$), (ii) the defendant does not actively defend himself ($P > 1$, $D = 1$), (iii) the prosecutor does not pursue his charge in court ($P = 1$, $D > 1$), and (iv) both litigants remain inactive and the court is fully arbitrary ($P, D = 1$). In the following, we focus on the most relevant case, case (i).[8]

The defendant, as the second-mover in court, reacts to the effort of the prosecutor and chooses his optimal level of effort D to defend his case. The defendant thus maximizes his utility function with respect to D, which yields his reaction function, D^R:

$$D^R = \arg\max_D \left[-X\left(1 - \frac{D}{P+D}\right) - D \right] = -P + \sqrt{XP}.$$

The defendant receives an expected disutility, dependent on the crime X, when losing the case with probability $1 - D/(P+D)$, and incurs effort costs D. Clearly, his optimal reaction strictly increases with the severity of the crime, and will eventually decrease for high effort levels of the prosecutor. Note that $D^R > 1$ always holds in the standard case, case (i).

The prosecutor, as the first-mover in court, anticipates the optimal reaction of the defendant and chooses his optimal level of effort P to prevail in court. As the prosecutor does not know the defendant's true type, he has to form (rational) beliefs μ about the defendant's guilt. We specify the prosecutor's belief as $\mu(G|q,s)$, which denotes the believed probability that the defendant is truly guilty (G), given the observed rejection of the plea offer q by the defendant and the observed evidence signal s. Given the defendant's behavior D^R and his beliefs μ, the prosecutor's utility function $U_P(P)$ is defined by

$$\begin{aligned} U_P(P) = {} & \mu(G|q,s)\left[X\frac{P}{P+D^R} - (c+d)X\left(1 - \frac{P}{P+D^R}\right)\right] \\ & + (1-\mu(G|q,s))\left[(-b)X\frac{P}{P+D^R} - cX\left(1 - \frac{P}{P+D^R}\right)\right] - P. \end{aligned}$$

[7] This assumption stresses the adversarial nature of the legal system. It also implies that, in the case of equal effort of the litigants, the resulting probability of success would be 50 percent. This specification could easily be altered to produce a higher probability of winning for the prosecutor, capturing effects of further factual evidence, testimonies, or superior prosecutor resources (see, e.g., Tullock, 1975, p. 752). However, our results in equilibrium would be qualitatively unaffected.

[8] Case (ii) simply allows the prosecutor to achieve a higher probability of winning, case (iii) would hardly be litigated and implies a lower probability, and case (iv) only yields a constant verification probability as in the traditional enforcement models. An analysis of the remaining cases can be obtained from the author upon request.

Maximizing with respect to P then yields the optimal effort of the prosecutor, P^*, with

$$P^* = \underset{P}{\operatorname{argmax}}[U_P(P)] = \frac{1}{4}X(\mu(G|q,s)(1+d+b)-b+c)^2. \tag{1}$$

The prosecutor's effort in court under uncertainty thus increases with the severity X of the crime, his belief μ about the defendant's guilt, and the expected loss when losing the trial or when failing to convict a guilty defendant. His effort under uncertainty decreases with increasing disutility from convicting an innocent defendant.

The equilibrium strategies $[P^*;D^R]$ of the litigants in the court subgame then produce the probability $\pi_P(\mu)$ of success for the prosecutor, contingent on his beliefs μ, as

$$\pi_P(\mu) = \frac{1}{2}(\mu(G|q,s)(1+d+b)-b+c). \tag{2}$$

The prosecutor's probability of winning the case in court under uncertainty thus increases with his beliefs and the expected reputational costs of losing the trial, and decreases with increasing disutility of a wrongful conviction. Clearly, information asymmetry produces a strategic disadvantage for the prosecutor and plagues both his effort and his chances in court. The more strongly the prosecutor believes the defendant to be guilty, the more confidently he can pursue his charge and win the case. Due to uncertainty in the courtroom, the prosecutor wins any given trial with a positive probability, which may imply either a correct or a wrongful conviction. In contrast to Baker and Mezzetti (2001), the specified court itself shows no positive verifiability to distinguish between guilty and innocent defendants. Thus, our modeled adversarial court totally relies on the behavior and capability of the prosecutor to be welfare-improving.

4.1.2 Stage III: The Charge

The prosecutor observes two signals about the defendant's type at stage III. First, he learns that the plea offer q was rejected. Second, he receives an exogenous evidence signal s during the following investigations.

The generated evidence in the case produces a dichotomous signal $s \in \{\overline{s};\underline{s}\}$ about the defendant's true type, with $\overline{s}$ suggesting that the defendant is potentially guilty and $\underline{s}$ indicating an innocent defendant. For simplicity, we follow Baker and Mezzetti (2001) and assume that the signal $\underline{s}$ reveals with certainty that the defendant is actually innocent. In other words, the prosecutor interprets this signal as clear proof that the defendant cannot have committed the crime, such as a watertight alibi. While a truly guilty defendant can never provide a rock-solid proof of his innocence, the investigating prosecutor reveals such evidence for the truly innocent defendant with positive probability, σ. Accordingly, factual evidence fails to show true innocence with probability $1-\sigma$. We specify $\text{prob}(\underline{s}|G) = 0$ and

$\sigma = \text{prob}(\underline{s}|I) > 0$. We regard σ as the quality of the generated evidence signal, which can be affected by prosecutorial resources and power, procedural rules, previous investigations by the police, and the nature of the crime.

Based on his updated beliefs, the prosecutor now decides to charge the defendant with probability $\theta(q,s)$ for a given rejection of the plea offer q and the evidence signal s. Trivially, the prosecutor will never charge on the signal $\underline{s}$, which indicates the defendant's innocence, as this implies a certain disutility from effort costs and either from convicting the innocent or from losing the trial.[9] However, the prosecutor will charge on the signal $\overline{s}$ with belief $\mu = \mu(G|q,\overline{s})$ if and only if

$$\begin{aligned} U_P(q,\overline{s}) = {} & \mu\theta(q,\bar{s})\big[\pi_P(\mu)X - (1-\pi_P(\mu))(c+d)X\big] \\ & -(1-\mu)\theta(q,\overline{s})\big[\pi_P(\mu)bX + (1-\pi_P(\mu))cX\big] \\ & -\theta(q,\overline{s})P^* > -\mu dX. \end{aligned}$$

Inserting the conditions (1) and (2) and some further simplifications now yield

$$\mu(G|q,\overline{s}) > \frac{2\sqrt{c}-c+b}{1+b+d} = \mu_{\min}. \tag{3}$$

Thus, the prosecutor will only charge the defendant if his beliefs about the defendant's guilt are sufficiently strong. The condition (3) imposes a lower threshold for the prosecutor's beliefs to actually move to court. The higher the disutility from convicting an innocent defendant or the higher the expected reputational cost from losing a case, the more convinced the prosecutor has to be that the suspect is indeed guilty.

4.1.3 Stage II: The Acceptance

The defendant can accept or reject an offered plea bargain q of the prosecutor. Let $G(q)$ be the probability that the guilty defendant rejects the offer, and $I(q)$ the probability that the innocent defendant rejects it. A defendant who rejects the plea offer receives a disutility through the expected sentence and costs through litigation effort only if the prosecutor actually decides to put him to trial. Accepting the plea bargain however implies a certain punishment q for the defendant. The guilty defendant chooses a strategy $G(q)$ to maximize his utility, specified by

$$U_g(\cdot) = -G(q)\theta(q,\overline{s})\big[\pi_P(\mu(G|q,\overline{s}))X + D^*\big] - (1-G(q))q.$$

In the same manner, the innocent defendant chooses his strategy $I(q)$ to maximize his expected utility, given as

$$U_i(\cdot) = -I(q)(1-\sigma)\theta(q,\overline{s})\big[\pi_P(\mu(G|q,\overline{s}))X + D^*\big] - (1-I(q))q.$$

[9] This implies that even if the evidence signal s may not be observable to the defendant, he can infer that the prosecutor received the signal $\overline{s}$ whenever he is charged.

As a distinct feature, only the innocent defendant benefits from improved evidence in the case, σ, and thus is less likely to face a charge upon rejecting the bargain. Given these considerations, guilty and innocent defendants may choose different strategies for the plea bargain. Consequently, the defendant's decision to accept or reject the plea offer is potentially informative to the prosecutor.

4.1.4 Stage I: Plea Offer

A perfect Bayesian equilibrium (PBE) for the prosecution game consists of the strategies $\{I^*(q), G^*(q), D^*, q^*, \theta^*, P^*\}$ and the beliefs $\mu^*(G|q,s)$ such that, "at any stage of the game, strategies are optimal given the beliefs, and the beliefs are obtained from the equilibrium strategies and observed actions using Bayes' rule" (Fudenberg and Tirole, 1991, p. 326).

4.2 Equilibria under the Assumption of Rational Behavior

Before introducing limited rationality into the game, we want to distinguish our model setup from the established literature on plea bargaining. It has been well known since Grossman and Katz (1983) that a separating equilibrium cannot exist. In Baker and Mezzetti (2001), the authors show that for low values of the crime, $x \leq \underline{x}$, a pooling equilibrium exists where all defendants reject the plea offer and the prosecutor never charges. For higher values of the crime, a semiseparating equilibrium exists where some guilty defendants accept the plea bargain, all other defendants reject it, and the prosecutor brings the case to court if he observes the signal $\overline{s}$. We show that these major findings still hold, but further conclusions can be made.

PROPOSITION 1 *Given a case with $\phi < \phi_{\min}$, a pooling PBE exists with $I(q) = 1$, $G(q) = 1$ and $\theta(q,s)0 =$ for $q \geq 0$, independent of the value X of the crime.*[10]

PROOF The prosecutor updates his belief about the defendant's guilt when observing the rejection of the plea deal and the signal $\overline{s}$. He will drop the case if his updated belief falls below $\mu_{\min}$. Using (3), this happens if

$$\frac{\phi}{\phi + (1-\phi)(1-\sigma)} < \frac{2\sqrt{c} - c + b}{1 + b + d}.$$

Thus, the prosecutor will never move to court if

$$\phi < \frac{(1-\sigma)\left(2\sqrt{c} - c + b\right)}{1 + b + d - \sigma\left(2\sqrt{c} - c + b\right)} = \phi_{\min}$$

applies. The defendants optimally react with $I(q) = 1$ and $G(q) = 1$ for all $q \geq 0$. *Q.E.D.*

[10] Also, trivial separating PBEs then exist for a deal $q = 0$ with either $I = 1$ and $G = 0$, or $I = 0$ and $G = 1$.

This finding shows that plea bargaining cannot serve as a screening device if the ex ante probability of a guilty defendant is too low to make a charge favorable for the prosecutor. This particularly stresses the relevance of competent police investigations (which determine ϕ) for the prosecutorial office. As $\partial\phi_{\min}/\partial\sigma < 0$ applies, a better evidence signal reduces uncertainty for the prosecutor and thus relaxes the threshold $\phi_{\min}$. Moreover, a low value of the crime is clearly no limitation on the screening process. We find it comforting that, in contrast to the BM model, our approach shows that even crimes with smaller X can be prosecuted, and thus may be potentially deterred by the criminal justice system.

PROPOSITION 2 *Given a case with $\phi \geq \phi_{\min}$, then the following strategies and beliefs constitute a semiseparating PBE:*

$$G^*(q) = \begin{cases} 1 & \text{if } q > q^*, \\ \gamma^* & \text{else}, \end{cases} \quad \text{with } \gamma^* = \frac{(1-\phi)(1-\sigma)\left(2\sqrt{c}-c+b\right)}{\phi\left(1-2\sqrt{c}+c+d\right)};$$

$$I^*(q) = 1; \quad D^* = X\left(\sqrt{c}-c\right) \geq 1; \quad q^* = X\left(2\sqrt{c}-c\right);$$

$$\theta^*(q,\underline{s}) = 0; \quad \theta^*(q,\overline{s}) = \begin{cases} 1 & \text{if } q \geq q^*, \\ \dfrac{q}{X\pi_P(\mu(G|q,\overline{s})) + D^*} & \text{else}; \end{cases}$$

$$P^* = Xc \geq 1;$$

$$\mu^*(G|q,\underline{s}) = 0 \text{ for all } q; \quad \mu^*(G|q,\overline{s}) = \begin{cases} \dfrac{\phi}{\phi + (1-\phi)(1-\sigma)} & \text{if } q > q^*, \\ \dfrac{\gamma\phi}{\gamma\phi + (1-\phi)(1-\sigma)} & \text{else}. \end{cases}$$

PROOF The innocent defendant accepts any plea offer with

$$q \leq (1-\sigma)\theta(q,\overline{s})[\pi_P(\mu(G|q,\overline{s}))X + D^*] = q_1,$$

and the guilty defendant accepts any plea offer with

$$q \leq \theta(q,\overline{s})[\pi_P(\mu(G|q,\overline{s}))X + D^*] = q_2.$$

Given a plea offer q that satisfies $q = q_2 > q_1$, all innocent defendants will reject q, $I^*(q) = 1$, and the guilty defendants reject q with positive probability γ. Firstly, the prosecutor becomes indifferent between charging the defendant and dropping the case, when q is rejected and $\overline{s}$ is observed if and only if the condition (3) is binding: $\mu(G|q,\overline{s}) = (2\sqrt{c}-c+b)/(1+b+d)$. Given the updated belief

$$\mu = \frac{\gamma\phi}{\gamma\phi + (1-\phi)(1-\sigma)},$$

modified with the probability γ that the guilty defendant actually rejects the plea offer, we solve for γ and find

$$\gamma^* = \frac{(1-\phi)(1-\sigma)\left(2\sqrt{c}-c+b\right)}{\phi\left(1-2\sqrt{c}+c+d\right)},$$

which is the mixed strategy for the randomizing guilty defendant. Secondly, the guilty defendant randomizes between accepting and rejecting the plea offer q if

$$q = q_2 = \theta(q,\overline{s})[\pi_P(\mu(G|q,\overline{s}))X + D^*].$$

The mixed strategy for the randomizing prosecutor thus is

$$\theta(q,\overline{s}) = \frac{q}{X\pi_P(\mu(G|q,\overline{s})) + D^*}.$$

As the prosecutor is indifferent on the equilibrium path between going to court and dropping the case, any $q > q_2$ would eliminate the self-selection and, due to court costs, cannot be favorable for the prosecutor. Any $q < q_2$ only reduces his equilibrium payoff. *Q.E.D.*

This finding demonstrates that the previously established semiseparating perfect Bayesian equilibrium in a plea-bargaining game (see, e.g., Baker and Mezzetti, 2001) also holds when adversarial litigation is seen as a contest, i.e., when the level of court accuracy depends on the prosecutor's performance under uncertainty. In addition to the BM framework, our rent-seeking approach yields further valuable insights (see the table). First, we can calculate the probability of the prosecutor prevailing in court on the equilibrium path as $\pi_P(\mu^*) = \sqrt{c}$. This implies that higher reputational costs c of losing in court lead to better prosecutorial performance in the semiseparating equilibrium. This is not surprising, as the prosecutor is made indifferent by the mixing strategy of the guilty defendant between going to court and dropping the case. Once in court, it is the reputational concern that eliminates this indifference and motivates positive prosecutorial effort. Second, higher reputational concerns and thus higher performance also enable the prosecutor to extort higher plea deals $q^* = X(2\sqrt{c}-c)$ that are successful in equilibrium. Distinct from the BM model, our analysis stresses the relevance of such "political costs of losing at trial" (Baker and Mezzetti, 2001, fn. 8) for efficient performance.[11]

Table
Comparative Statics Results

	ϕ	X	b	c	d	σ
$\phi_{\min}$	0	0	+	+	−	−
γ^{*1}	−	0	+	+	−	−
q^{*1}	0	+	0	+	0	0
π_p^{*1}	0	0	0	+	0	0

Note: [1] For the semiseparating equilibrium.

[11] Be reminded that $0 < c < 1$ applies, and that we focus our analysis on the case with positive party efforts in court; thus $P, D \geq 1$.

5 Hindsight-Biased Updating

In the following, we integrate a concept of hindsight bias into our model and study prosecutorial performance and plea bargaining under such limited rationality. Moreover, we will show that the semiseparating equilibria established in the literature may collapse when the prosecutor becomes too biased in hindsight.

5.1 Formal Concept

If the plea offer q is rejected by the defendant and the prosecutor observes the evidence signal s, he updates his beliefs about the defendant's type. Recalling the ex ante probability of a guilty defendant at this point, the prosecutor is subject to a potential bias in hindsight. In this case, his remembrance of the ex ante probability of guilt is unconsciously tilted towards the observed new information ("*memory distortion*"). Both the evidence signal s and the rejection of the plea deal q mean new information to the prosecutor and either can lead to such bias in hindsight.

We follow the approach proposed by Camerer, Loewenstein, and Weber (1989) and Biais and Weber (2009) to formally incorporate an intrapersonal hindsight bias into our prosecution model. The ex ante probability of facing a guilty defendant equals the common prior, ϕ. Assume that the prosecutor then learns new information η, which is dichotomous in nature with $\eta \in \{0;1\}$. This new information may be an indication either of the defendant's guilt ($\eta = 1$) or of his innocence ($\eta = 0$). For an unbiased prosecutor, the remembrance of the ex ante probability is unaffected by the new information. A prosecutor who is completely biased in hindsight, however, falsely believes that the defendant was guilty with certainty beforehand when observing $\eta = 1$, and that the defendant's innocence was already certain when he learns $\eta = 0$. More generally, the prosecutor fails to correctly remember this initial estimate under hindsight bias, as his recollection is tilted towards certain guilt (innocence) when observing information $\eta = 1$ ($\eta = 0$). This can be modeled by defining the distorted remembrance of the common prior, $\phi_{HB}(\omega)$, as the weighted average of the true ex ante probability of guilt and the new information η:

$$\phi_{HB} = \omega\eta + (1-\omega)\phi. \tag{4}$$

The distorted remembrance is contingent on the parameter $\omega \in [0;1]$, which captures the magnitude of the hindsight bias. For $\omega = 0$, the decision-maker is unbiased. Note that equation (4) can also be interpreted in the tradition of Jacowitz and Kahneman (1995), who propose a well-testable empirical measure for exploring such anchoring effects.[12]

During the game at stage III, the prosecutor receives two signals s and q that provide new information to him. However, the two signals impact his beliefs in opposing ways. Observing the rejection of the plea deal q is an (imperfect) signal

[12] Interpreting the evidence signal as the mental anchor that biases the correct remembrance of the common prior, we solve equation (4) for ω, which yields Kahneman's anchoring index $\omega = (\phi_{HB} - \phi)/(\eta - \phi)$.

of innocence (see, e.g., Grossman and Katz, 1983; Baker and Mezzetti, 2001), as the optimal deal offer q always makes the innocent defendants reject, but some guilty defendants also reject q. For this case, we interpret this new information as $\eta = 0$. Observing the evidence signal $\overline{s}$, however, is an (imperfect) signal of guilt, as prosecutorial investigations always yield $\overline{s}$ when the defendant is truly guilty, but sometimes this also occurs for the innocent defendant. We would interpret such new information as $\eta = 1$. Which interpretation of η is prevailing when observing both q and $\overline{s}$, however, remains an empirical question. We will thus present the theoretical implications of a hindsight bias (i) for the evidence signal ($\eta = 1$) and (ii) for the rejection of the deal ($\eta = 0$) separately in the next section.

We believe that whenever hindsight bias is present, the capability of the decision-maker to learn from observations correctly is distorted (see also Biais and Weber, 2009, p. 1028). Given new information, economic agents update their ex ante beliefs according to Bayes's rule. Hindsight-biased decision-makers, however, will have to rely on their distorted remembrance of the ex ante estimate, and are thus subject to *biased Bayesian learning*. In other words, as the remembrance is tilted towards the actual observation, hindsight bias leads to overinference from new information (so-called "double counting"). Moreover, the hindsight-biased decision-maker will usually err when estimating the true ex ante probability from a random sample.[13] We assume limited rationality to apply in such a way that the prosecutor is not aware of being biased in foresight; thus, e.g., he would be surprised about his incorrect inference from case evidence if the true guilt of the defendants were revealed.

5.2 Hindsight Bias on the Evidence Signal s

We consider the case that the prosecutor is subject to hindsight bias when observing the evidence signal s. Due to hindsight bias, he is then prone to a distorted memory when observing $\overline{s}$, and thus the condition (4) together with $\eta = 1$ specifies the hindsight-biased ex ante probability $\phi^s_{HB}(\omega) = \omega + (1-\omega)\phi$. The behavior of the prosecutor is then determined by his biased belief $\mu(G|q,\overline{s},\omega)$, which yields the following implications for the equilibria of the prosecution game.

First, the threshold to bring the case to court, $\phi_{\min}$, is sensitive to the extent of the hindsight bias ω. To see this, remember that the prosecutor is indifferent between charging and dropping the case if his updated belief $\phi^s_{HB}/(\phi^s_{HB} + (1-\phi^s_{HB})(1-\sigma))$ is equal to $\mu_{\min}$. Using (3) and inserting (4) with $\eta = 1$ for ϕ^s_{HB} then yields the threshold as

$$\phi_{\min}(\omega) = \frac{1}{1-\omega}\frac{(1-\sigma+\omega\sigma)\left(2\sqrt{c}-c+b\right)-\omega(1+b+d)}{1+b+d-\sigma\left(2\sqrt{c}-c+b\right)}.$$

Interestingly, we find $\partial\phi_{\min}/\partial\omega < 0$. Thus, the threshold $\phi_{\min}$ is lowered and the prosecutor becomes more confident in going to court if hindsight bias in-

[13] The biased decision-maker may not err if and only if the two overinference distortions cancel each other out.

creases. As hindsight bias induces overinference from the observed evidence signal, the prosecutor deems it more likely that the defendant is guilty than a rational decision-maker would. This potentially produces an inefficiency whenever $\phi_{\min}(\omega > 0) < \phi < \phi_{\min}(\omega = 0)$ applies, as the hindsight-biased prosecutor then charges cases that a rational prosecutor would never pursue. To put it differently, the hindsight-biased prosecutor is overly confident in confronting guilty defendants while he mostly charges innocent ones.

Second, self-selection of guilty defendants in the semiseparating equilibrium increases with the hindsight bias. For this, we take the optimal mixing strategy of the guilty defendant γ^* from Proposition 2, and insert (4) with $\eta = 1$ for ϕ^s_{HB}. Then, the probability of a guilty defendant rejecting q is

$$\gamma^*(\omega) = \frac{(1-\omega-(1-\omega)\phi)(1-\sigma)\left(2\sqrt{c}-c+b\right)}{(\omega+(1-\omega)\phi)\left(1-2\sqrt{c}+c+d\right)}. \tag{5}$$

Generally, the ability of guilty defendants to imitate the innocent defendants is limited because increased rejections of plea deals make the charge more favorable to the prosecutor and this further increases prosecutor performance. Our model thereby reveals a positive effect of hindsight bias, as we find $\partial\gamma^*/\partial\omega < 0$. This implies that increased hindsight bias makes the prosecutor more confident in his charge, and makes it more difficult for the guilty defendant to mimic the behavior of innocent individuals. Thus, quite surprisingly, hindsight bias on the evidence signal s amplifies the self-selection mechanism of plea bargaining. This improved separation means that the number of type II errors (wrongful acquittals) in court decreases with increasing ω, due to the growing number of deals, and the number of type I errors (wrongful convictions) stays constant.[14]

These two findings show that a hindsight bias on the evidence signal s for high values of the ex ante probability, $\phi \geq \phi_{\min}$, improves self-selection and reduces error costs. For lower values, $\phi < \phi_{\min}$, this effect gets more ambiguous. Then, the net gains due to enhanced self-selection will erode and eventually turn negative through increased wrongful convictions when ϕ (i.e., the ex ante share of guilty defendants) gets smaller.

A perfect separation can be achieved if and only if an extreme hindsight bias fully eliminates the former memory ($\omega = 1$). Only then does the prosecutor believe that all defendants are guilty with certainty, and then he will always charge when observing $\overline{s}$. Consequently, a plea deal q^* exists that all guilty defendants accept and the innocent defendants reject. Also note that, in contrast to the semiseparating equilibrium where the prosecutor is indifferent about the charge, his performance in court now increases. Thus, the probability of winning in trial is higher for the prosecutor, and his optimal deals are tougher for the defendants. As only innocent defendants reject the deal, however, this implies that the number of wrongful con-

[14] Given the equilibrium path, type I and type II errors can only occur inside the court: no innocent defendant wrongfully accepts a plea offer, and all guilty defendants who reject the offer are charged by the prosecutor.

victions is larger by far. Given that this only holds for the extreme case, $\omega = 1$, we believe this outcome is of little practical relevance.

PROPOSITION 3 *There is a separating equilibrium if and only if* $\omega = 1$ *applies where the defendant always reveals his true type, given that the prosecutor makes a plea offer*

$$q^* = X\pi_P(\mu(G|q,\overline{s},\omega)) + D^*$$

and his belief is $\mu^*(G|q,\overline{s},\omega = 1) = 1$.

PROOF We consider the separating solution with $I(q) = 1$ and $G(q) = 0$. The condition (5) shows that $G(q) = 0$ can only apply if $\omega = 1$. Then, for a deal $q^* = X\pi_P(\mu(G|q,\overline{s},\omega) + D^*$, only the guilty defendants would accept it, as the expectancy value in court is lower for the innocent defendants due to the evidence signal σ. Given his biased remembrance of $\phi^s_{HB} = 1$, the prosecutor does not expect to observe any rejection in equilibrium. If there is a rejection, he will have to believe that this can only be a guilty defendant, and move to court. To see this, imagine that the prosecutor's belief allows for small trembles ε in the equilibrium strategies of the other player (see, e.g., Kreps and Wilson, 1982). A guilty defendant may then reject the deal by mistake with probability ε. Thus, the (biased) ex post belief yields $\mu(G|q,\overline{s},\omega) = \varepsilon\phi^s_{HB}/(\varepsilon\phi^s_{HB} + (1-\phi^s_{HB})(1-\sigma)) = 1$, which makes the prosecutor confident in the guilt of the defendant. *Q.E.D.*

5.3 Hindsight Bias on the Rejection of the Plea Deal q

In the following we examine the case where the prosecutor is subject to hindsight bias when observing the rejection of the plea offer q. As the deal rejection serves as an (imperfect) signal of innocence, we specify the hindsight bias with $\eta = 0$ in (4); thus memory distortion produces the biased ex ante probability as $\phi^q_{HB}(\omega) = (1-\omega)\phi$. The behavior of the prosecutor is then determined by his biased belief $\mu(G|q,\overline{s},\omega)$. As the effect of this overinference on the signal q is clearly negative for the prosecutor's confidence in court, the following implications are straightforward.

Again, the prosecutor's threshold to move to court is affected by the extent of the bias ω. Equating $\mu_{\min}$ from (3) with the updated belief $\phi^q_{HB}/(\phi^q_{HB} + (1-\phi^q_{HB})(1-\sigma))$ then yields as threshold

$$\phi_{\min}(\omega) = \frac{1}{1-\omega}\frac{(1-\sigma)\left(2\sqrt{c}-c+b\right)}{1+b+d-\sigma\left(2\sqrt{c}-c+b\right)}. \tag{6}$$

In contrast to the previously discussed hindsight bias on s, we find $\partial\phi_{\min}/\partial\omega > 0$. As the prosecutor is less confident when observing q, he decides to take less cases to court. Consequently, many guilty defendants that a rational prosecutor would charge will no longer see trial.

Furthermore, also the self-selection of the guilty defendants deteriorates. Using ϕ^q_{HB} to determine the optimal mixing strategy γ^* of the guilty defendant from Proposition 2, we find the probability of rejection q as

$$\gamma^*(\omega) = \frac{(1-(1-\omega)\phi)(1-\sigma)\left(2\sqrt{c}-c+b\right)}{(1-\omega)\phi\left(1-2\sqrt{c}+c+d\right)}.$$

As $\partial\gamma^*/\partial\omega > 0$ applies, more guilty defendants will reject the plea deal and move to trial. This follows the rationale that rejecting the deal is (overly) interpreted as a signal for innocence, which reduces prosecutorial performance in the court contest. This makes trial more attractive for the guilty defendant. While performance in the semiseparating equilibrium is unaffected, hindsight bias on observing the rejection of q degrades its self-selection capability.

In general, less charges and also reduced self-selection primarily imply more type II errors (wrongful acquittals). Type I errors (wrongful convictions) are reduced to some extent, as some cases against truly innocent individuals are now dropped. Moreover, if the hindsight bias is too strong, the semiseparation solution collapses.

PROPOSITION 4 *Given a sufficiently strong hindsight bias $\omega \geq \underline{\omega}^q$, a semiseparating equilibrium with $\theta(q,\overline{s}) = 1$ and $q^* > 0$ cannot exist.*[15]

PROOF The prosecutor will never expect to benefit from going to court if $\phi_{\min}(\underline{\omega}^q) = 1$ holds for some bias $\underline{\omega}^q$. As $\partial\phi_{\min}/\partial\omega > 0$ applies for $0 < \omega < 1$, the prosecutor will never move to court if $\omega > \underline{\omega}^q$. Equating (6) with one yields

$$\omega \geq 1 - \frac{(1-\sigma)\left(2\sqrt{c}-c+b\right)}{1+b+d-\sigma\left(2\sqrt{c}-c+b\right)} = \underline{\omega}^q.$$

As the prosecutor will never move to court, no plea deal $q > 0$ will be acceptable for the defendants. *Q.E.D.*

We find it remarkable that a sufficiently strong hindsight bias on the rejection of plea deals effectively rules out the semiseparating equilibrium. Given the induced lack of confidence on the part of the biased prosecutor, he finds himself unable to credibly commit to trial. As a consequence, plea bargaining fails as a screening device.

Our analysis of hindsight-biased information updating shows that the self-selection mechanism of plea bargaining is particularly vulnerable to limited rationality in the interpretation of the signal q. Screening is then less effective in the semiseparating equilibrium, and less cases are taken to court. If the bias gets too strong, only the uninformative pooling equilibrium remains where no cases are taken to trial. The effect of a hindsight bias on the evidence signal s is more ambiguous, and sometimes even favorable. When the ex ante probability is too low

[15] Note that the trivial separating equilibrium for $q = 0$ still exists.

for the rational prosecutor, $\phi < \phi_{\min}$, then the bias produces more charges against innocent individuals, but also forces some guilty defendants to accept the plea deal who otherwise would have enjoyed certain acquittal. If $\phi > \phi_{\min}$, then a hindsight bias on the evidence signal improves self-selection and reduces error costs.

6 Policy Implications

Given the theoretical effect of hindsight bias on the verification of the defendant's guilt and the elevated position of the prosecutorial body in criminal procedure, our model yields three relevant insights for legal policy.

Nature and Distribution of Hindsight Bias among Prosecutors. As the effect of the hindsight bias depends on whether the bias occurs in the interpretation of the observed evidence or in the rejection of the plea deal, empirical research is needed to identify which is the more relevant scenario. Given the high rates of plea deals in many countries, we suppose that hindsight bias is primarily caused by the observed evidence. Either way, hindsight bias may persist among the prosecutorial body. The established literature (see, among others, Fischhoff, 1975; Camerer, Loewenstein, and Weber, 1989; Pezzo, 2003) suggests that this cognitive phenomenon is difficult to overcome by learning from experience, even if agents eventually realize that they are biased. Some studies (see, e.g., Musch, 2003; Roese and Vohs, 2012) point out that decision-makers nevertheless differ in their personal vulnerability to hindsight bias. More specifically, current research also associates specific personality traits with a higher degree of hindsight bias, such as a tendency for favorable self-presentation or a personal need for predictability and control. It appears reasonable to assume that strong preferences for order and control may be particularly widespread among public enforcement agents.

Given that hindsight bias cannot be (fully) avoided, policy-makers and chief prosecutors should be aware of the nature and distribution of hindsight bias among their prosecutors. As psychological tests for high-level applicants are a routine procedure of human resource management, it appears feasible and promising to apply such methods (see, e.g., Camerer, Loewenstein, and Weber, 1989) to the prosecutorial body to gain a better picture of the individuals' vulnerability to hindsight bias. Whether the influence of hindsight bias on prosecutors, due to their institutional power and discretion to select cases, is more worrisome than hindsight bias among judges or juries needs to be addressed by future research.

Limitations of Review. Institutions may achieve a separation between less and more biased agents. For the case of investment bankers, Biais and Weber (2009) revealed that financial markets reward the more unbiased traders. Unfortunately, it appears doubtful whether this example carries over to criminal procedure: in contrast to traders, prosecutors do not learn the "true state" of a case and are not rewarded for "correct" decisions. Performance criteria like managing one's caseload,

concluding cases quickly, and conserving scarce resources do not necessarily reward the more unbiased prosecutors. It is thus questionable whether successful legal careerists, such as chief prosecutors and appellate judges, are actually less biased in hindsight and can serve as an effective monitoring institution. Furthermore, the decision to appeal a conviction also depends on nonlegal factors, for example, individual wealth, attorney fees, or the stakes of the case. Then, the numbers of appeals and reversals only provide a very limited indication of the prosecutor's individual bias. Overall, the appeals process may prove rather ineffective in curbing the number of hindsight-biased decisions.

Sensitivity to Wrongful Convictions. Consider that hindsight bias is primarily caused in the interpretation of factual evidence. Then our results show that the favorability of the outcome is mainly dependent on the accuracy of the initial investigations by the police force. In other words, when the guilt of the defendant is "rather probable" from the beginning ($\phi \geq \phi_{\min}$), then screening is unambiguously improved through the biased confidence of the prosecutor. Otherwise, the favorable self-selection of guilty defendants comes at the cost of increased type I errors. Policy-makers and chief prosecutors then face a tradeoff, and the optimal allocation of prosecutors depends on society's sensitivity to wrongful convictions. Given that the assessment of "rather probable" guilt may be misleading and delusive in practice, we think that society's sensitivity to type I errors can provide more reliable guidance.

For minor cases that show limited punishments and that are usually easy to resolve, such as larceny, burglary, or mischief, the increased self-selection of guilty defendants through plea deals and saved public resources is desirable and error costs appear tolerable. Chief prosecutors thus could allocate the more hindsight-biased prosecutors to these cases, and benefit from their inflated bargaining power.[16] For cases with high stakes, tough punishments, and typically less clear evidence, such as rape or murder, social costs of potential errors will likely dominate the positive effects of increased self-selection. Unbiased prosecutors will then be able to evaluate the often ambiguous evidence, and will rationally decide whether to bring a case to court. Chief prosecutors should assign the least biased prosecutors to these cases in order to mitigate error costs. However, the net welfare effect can be less favorable if innocent defendants are considered to be averse to risk (see, e.g., Kobayashi and Lott, 1996).

[16] Note that "easy to resolve" is a rather treacherous criterion for any social planner when hindsight bias is present.

7 Conclusion

In this paper, we present a plea-bargaining model where adversarial courts are stylized by a litigation contest and where (limitedly) rational prosecutors seek to convict the guilty defendants.

The bargaining power of the prosecutor hinges on the credibility of his threat to take the case to trial when the deal offer is rejected. The court is then often regarded as the "verifier of last resort," and its existence strengthens the bargaining position of the prosecutor in the eyes of the guilty defendant. In adversarial prosecution, however, the outcome of trial is largely dependent on the behavior of the litigating parties themselves. As successful self-selection of guilty defendants through accepted plea deals implies that the share of truly innocent defendants in court increases, the confidence of the prosecutor in his case in court is weakened, and so is his threat in the plea bargain.

Modeling adversarial litigation as a sequential rent-seeking contest where the charging prosecutor acts as the less informed first-mover, we demonstrate that the general findings of the plea-bargaining literature still hold. For a low ex ante probability of a guilty defendant, there is a pooling equilibrium where the prosecutor never charges, and for higher values of the prior a semiseparating equilibrium exists where some guilty defendants reveal themselves and accept the deal. Moreover, our results emphasize the importance of reputational concerns by the prosecutor for the semiseparating equilibrium. In this mixed-strategy equilibrium the prosecutor is indifferent between charging the defendant and dropping the case, but once he is inside the court reputational concerns become his main driver to exhibit strong performance. Consequently, we find that these reputational concerns affect the equilibrium path. For policy-makers who may determine such "political costs" (Baker and Mezzetti, 2001, fn. 8), our analysis reveals a trade-off: the higher the prosecutor deems the reputational costs of losing a case, the higher is the resulting probability of winning in court and the tougher are the attained plea deals against the guilty defendants in the semiseparating equilibrium. At the same time, however, higher reputational costs make the prosecutor take less cases to court.

Prosecutors are no perfect Bayesian decision-makers. Nevertheless, they have to (rationally) assess informative signals throughout the pretrial proceedings, such as the observed rejection of the plea deal and potentially new factual evidence in the case. Under hindsight bias, decision-makers are overly susceptible to what they observe and are prone to biased Bayesian learning. In the first formal model of a hindsight-biased prosecutor, we find that the effect of this behavioral bias on the equilibrium path largely depends on what kind of information causes the bias. In our analysis, we distinguish between the observation of new evidence and the rejection of the plea deal.

For the former case, new incriminating evidence makes a defendant look guiltier than before. Then, a hindsight-biased prosecutor becomes even more confident under uncertainty and acts more boldly in the plea bargaining. This puts pressure on the guilty defendants and thus amplifies the desirable self-selection in the semi-

separating equilibrium. At the same time, decision errors increase, as the prosecutor will also press charges that a rational prosecutor never would consider. For such cases, hindsight bias induces additional social costs through more wrongful convictions. In contrast, if hindsight bias is caused by the observed rejection of the plea deal, we find a clearly negative effect on the performance of the prosecutor: the amount of self-selection is reduced in equilibrium, and less cases are taken to court. Moreover, if the hindsight bias is sufficiently strong, then no self-selection is possible and the semiseparating solution collapses. We thus conclude that the self-selection property of plea bargaining is particularly vulnerable to a limitedly rational interpretation of deal rejections. (Moderately) biased Bayesian learning with regard to incriminating evidence may for some cases even make more guilty defendants accept plea deals.

Whether hindsight bias among prosecutors is mainly caused by the observation of evidence or by the rejection of plea deals remains a question for empirical research. Policy-makers and chief prosecutors need to know the nature and distribution of this behavioral bias among the prosecutorial body. Only then can they allocate prosecutors to cases accordingly to make best use of bargaining and investigative abilities. Cases where society is typically sensitive to wrongful convictions and where evidence is often ambiguous, such as murder or rape charges, should be investigated by the least biased prosecutors. Even though other decision-makers in criminal procedures, such as juries and judges, are potentially subject to hindsight bias as well, the case of prosecutors appears particularly relevant, as they enjoy considerable institutional power and discretion in selecting cases.

References

Baker, Scott, and Claudio Mezzetti (2001), "Prosecutorial Resources, Plea Bargaining, and the Decision to Go to Trial," *The Journal of Law, Economics, & Organization*, 17(1), 149–167.

Bar-Gill, Oren, and Omri Ben-Shahar (2009), "The Prisoners' (Plea Bargain) Dilemma," *Journal of Legal Analysis*, 1(2), 737–773.

Biais, Bruno, and Martin Weber (2009), "Hindsight Bias, Risk Perception, and Investment Performance," *Management Science*, 55(6), 1018–1029.

Bibas, Stephanos (2004), "Plea Bargaining Outside the Shadow of Trial," *Harvard Law Review*, 117(8), 2463–2547.

Bjerk, David (2007), "Guilt Shall Not Escape or Innocence Suffer? The Limits of Plea Bargaining when Defendant Guilt Is Uncertain," *American Law and Economics Review*, 9(2), 305–329.

Burke, Alafair S. (2007), "Prosecutorial Passion, Cognitive Bias, and Plea Bargaining," *Marquette Law Review*, 91(1), 183–211.

Camerer, Colin, George Loewenstein, and Martin Weber (1989), "The Curse of Knowledge in Economic Settings: An Experimental Analysis," *Journal of Political Economy*, 97(5), 1232–1254.

Christensen-Szalanski, Jay J. J., and Cynthia Fobian Willham (1991), "The Hindsight Bias: A Meta-Analysis," *Organizational Behavior and Human Decision Processes*, 48(1), 147–168.

Covey, Russel D. (2009), "Signaling and Plea Bargaining's Innocence Problem," *Washington & Lee Law Review*, 66(1), 73–130.

Fischhoff, Baruch (1975), "Hindsight ≠ Foresight: The Effect of Outcome Knowledge on Judgment under Uncertainty," *Journal of Experimental Psychology: Human Perception and Performance*, 1(3), 288–299.

— and Ruth Beyth (1975), " 'I Knew it Would Happen': Remembered Probabilities of Once–Future Things," *Organizational Behavior and Human Performance*, 13(1), 1–16.

Franzoni, Luigi Alberto (1999), "Negotiated Enforcement and Credible Deterrence," *The Economic Journal*, 109(458), 509–535.

Fudenberg, Drew, and Jean Tirole (1991), *Game Theory*, MIT Press, Cambridge (MA).

Garoupa, Nuno (2012), "The Economics of Prosecutors," in: Alan Harel and Keith N. Hylton (eds.), *Research Handbook on the Economics of Criminal Law*, Edward Elgar Publishing, Northampton (MA), pp. 231–242.

Glaser, Markus, Thomas Langer, and Martin Weber (2005), "Overconfidence of Professionals and Lay Men: Individual Differences Within and Between Tasks?" Working Paper 05-25, University of Mannheim, Mannheim.

Grossman, Gene M., and Michael L. Katz (1983), "Plea Bargaining and Social Welfare," *The American Economic Review*, 73(4), 749–757.

Jacowitz, Karen E., and Daniel Kahneman (1995), "Measures of Anchoring in Estimation Tasks," *Personality and Social Psychology Bulletin*, 21(11), 1161–1166.

Kahneman, Daniel, and Amos Tversky (1984), "Choices, Values and Frames," *American Psychologist*, 39(4), 341–350.

Kim, Jeong-Yoo (2010), "Credible Plea Bargaining," *European Journal of Law and Economics*, 29(3), 279–293.

Kobayashi, Bruce H., and John R. Lott, Jr. (1996), "In Defense of Criminal Defense Expenditures and Plea Bargaining," *International Review of Law and Economics*, 16(4), 397–416.

Kreps, David M., and Robert Wilson (1982), "Sequential Equilibria," *Econometrica*, 50(4), 863–894.

Madarász, Kristóf (2012), "Information Projection: Model and Applications," *The Review of Economic Studies*, 79(3), 961–985.

Musch, Jochen (2003), "Personality Differences in Hindsight Bias," *Memory*, 11(4–5), 473–489.

Pezzo, Mark V. (2003), "Surprise, Defence, or Making Sense: What Removes Hindsight Bias?" *Memory*, 11(4–5), 421–441.

Reinganum, Jennifer F. (1988), "Plea Bargaining and Prosecutorial Discretion," *The American Economic Review*, 78(3), 713–728.

Roese, Neal J., and Kathleen D. Vohs (2012), "Hindsight Bias," *Perspectives on Psychological Science*, 7(5), 411–426.

Schwartz, Edward P. (1995), "A Comment on the 'The Appeals Process as a Means of Error Correction,' by Steven Shavell," *Legal Theory*, 1(3), 361–363.

Shavell, Steven (1996), "Reply to a Comment on 'The Appeals Process as a Means of Error Correction'," *Legal Theory*, 2(1), 83–85.

Shavell, Steven M. (1995), "The Appeals Process as a Means of Error Correction," *The Journal of Legal Studies*, 24(2), 379–426.

Studdert, David M., Michelle M. Mello, William M. Sage, Catherine M. DesRoches, Jordon Peugh, et al. (2005), "Defensive Medicine among High-Risk Specialist Physicians in a Volatile Malpractice Environment," *JAMA*, 293(21), 2609–2617.

Tullock, Gordon (1975), "On the Efficient Organization of Trials," *Kyklos*, 28(4), 745–762.

Wasserman, David, Richard O. Lempert, and Reid Hastie (1991), "Hindsight and Causality," *Personality and Social Psychology Bulletin*, 17(1), 30–35.

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5. You go First! Coordination Problems and the Burden of Proof in Inquisitorial Prosecution.

(European Journal of Law & Economics 56: 403-422)

European Journal of Law and Economics (2023) 56:403–422
https://doi.org/10.1007/s10657-022-09757-2

You go first!: coordination problems and the burden of proof in inquisitorial prosecution

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Accepted: 27 October 2022 / Published online: 9 December 2022

Abstract

Prosecution of criminals is costly and subject to errors. In contrast to adversarial court procedures, in inquisitorial systems the prosecutor is regarded as an impartial investigator and an aide to the judge. We show in a sequential prosecution game of a Bayesian court that a strategic interaction between these two impartial agents exists where each player may hope to free ride on the other one´s investigative effort. This gives rise to inefficient equilibria. The model demonstrates that the effectiveness of some policy measures that intend to curb the free-riding problem critically depends on the assumed benevolence of the prosecutor. We find that, if policy makers are unable to infer the true preferences of the prosecutorial body, the high burden of proof in criminal law may reduce the probability of court errors. Our analysis, therefore, substantiates claims made in the literature that inquisitorial procedures are introduced to avoid wrongful acquittals.

Keywords Criminal justice · Reasonable doubt · Benevolent prosecutor · Court errors

JEL Classification K14 · K41

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1 Introduction

"Hannemann, geh du voran!" (engl. 'Hannemann, you go first') – a German saying[1]

The prosecution of criminals is costly and potentially erroneous. Given that one knows the law, being innocent or guilty to a crime is basically private information. Authorities may thus mistakenly convict an innocent person or set free a true offender. It is well-understood that such adjudicative errors produce a cost to society (see, e.g., Harris 1970, Tullock 1994, Rizzolli 2019), and that legal institutions should be designed in a way to minimize error and operating costs (see Spier, 2007, pp. 282 for an overview).

In adversarial (or 'partisan') legal systems, the prosecutor and the defendant´s advocates take opposing sides as they try to reveal information that strengthens their own prospect of winning. Pursuing their cause, such a "trial by battle" (Tullock 1975, p. 746) strongly motivates both parties to provide information to the judge. In inquisitorial legal systems, the prosecutor is not regarded as an advocate of one specific party to the case, but is expected to support the court in its search for the substantive truth (see, e.g., Garoupa 2011). In this perspective, the prosecutor is perceived as an impartial aide who runs the investigations (so-called '*Herrin des Ermittlungsverfahrens*') under the supervision of the benevolent judge (see Spier, 2007, pp.313). For law and economics scholars, a distinct weakness of the inquisitorial system is "its lack of incentives" (Kim 2013, p. 789) for rigorous investigations by the court. This paper contributes to this discussion and argues that its weakness lies not only in insufficient incentives, but also in a coordination problem between the two investigating agents, judge and prosecutor, of the inquisitorial tradition.

Given that no criminal justice system is without errors, many jurisdictions have attempted to balance type I and type II errors and therefore established the conviction threshold of 'beyond reasonable doubt'.[2] This threshold requires that a defendant can only be convicted as guilty when no reasonable doubts about the case remain.[3] Evidently, this standard of proof in criminal procedure is more restrictive than the 'more probable than not'-standard often applied for civil law cases (see, e.g., Kaye 2001). This reflects the widely accepted view that wrongful convictions of innocent individuals are regarded as more harmful to society than wrongful acquittals, and thus a higher conviction threshold is required to mitigate error costs (for an overview, see Andreoni 1991, and Tsur 2017). It is unclear, however, how

[1] This German saying "Hannemann, you go first" describes a situation where a group of people share a common goal, but everybody prefers that one of the others makes the unpleasant first move.

[2] Other procedural rules may affect the effective burden of proof, for example by excluding some evidence from trial (see, e.g., Dharmapala et al. 2013).

[3] For example, this high standard of proofs is expressed in Coffin v. US, 156 U.S. 432 (1895) and Woolmington v DPP (1935) UKHL 1. German criminal justice order requires the 'firm belief of the judge' (§ 261 StPO) for a conviction, which is often regarded as being specified by the German High Court ruling to "a usable degree of certainty which puts silence to any remaining doubts without fully eliminating them" (BGH 1993, IX ZR 238/91).

this 'reasonable doubt' threshold for a conviction affects investigative efforts in a system where two independent agents are to jointly solve the criminal case.

In this paper, we will show that the strategic interaction between two impartial investigating agents, the judge and the prosecutor, gives rise to inefficient equilibria in inquisitorial criminal procedure. Moreover, some policy instruments to mitigate this coordination problem are dependent on the prosecutor´s type: is the prosecutor impartial and seeks to avoid court errors, or is she opportunistic and maximizes gains from winning in trial? This theoretical finding is particularly worrisome whenever policy makers are unable to infer the true preferences of their prosecutors. In the following, we develop a sequential prosecution game in which both the prosecutor and the judge could perfectly reveal the true guilt of the defendant, but investigations create private effort costs. As a consequence, a free riding dilemma unfolds where each agent hopes to benefit from the other´s investigative effort. Following the formal concept of 'beyond reasonable doubt' by Tsur (2017), we analyze the impact of the standard of proof and reputational concerns on type I and type II errors and operating costs.

This paper is organized as follows: chapter 2 provides the basic framework of the model. We then conduct a normative analysis in chapter 3, and identify the equilibria to the game in chapter 4. We introduce the opportunistic prosecutor in chapter 5. Chapter 6 then discusses different policy instruments, and chapter 7 concludes this paper.

2 Inquisitorial prosecution model

Imagine a person, the defendant, who is accused of having committed a crime. Law demands the guilty defendants to be put to jail while the innocent defendants are to be acquitted. Given this setting, consider the criminal justice system as a prosecution game with two players, the prosecutor P and the Judge J, who seek to determine the actual guilt of the defendant. The defendant can either be guilty *(G)* or innocent *(I)*, and the ex-ante probability of a guilty defendant is defined as γ. All this is common knowledge.

Both players (P and J) may investigate the evidence to the case during the criminal proceedings. For simplicity, we assume that the investigative effort perfectly[4] reveals the defendant´s guilt or innocence, but induces effort costs c_P for the prosecutor and c_J for the judge. Due to the superior resources of the prosecutorial office and its closer cooperation with the police force, one may reasonably assume that the prosecutor can investigate the case at lower costs compared to the judge. Thus, we will consider the specification $c_P < c_J$ to further discuss the normative outcome

[4] This assumption ensures that any coordination problem between judge and prosecutor is not caused by imperfect investigative powers of the agents, but occurs even under the ideal conditions of perfect verification of evidence.

of the game.[5] Furthermore, we treat investigation effort of the players as substitutes here.[6] The prosecutor can either decide to investigate the case, and then only move to court if the defendant is found guilty, or drop the case, or charge the defendant without any examination of evidence. If the case is brought to court, the judge may either investigate the case himself, which then leads to a correct decision, or decide about the conviction or acquittal of the defendant without (further) investigations. However, whether the case was actually investigated beforehand or simply passed on to the judge remains private information of the charging prosecutor.[7]

The law, and society, demand the avoidance of wrongful convictions (type I error) and wrongful acquittals (type II errors). We assume that a false acquittal generates a loss to society of H, and society incurs a loss of αH, with $\alpha > 1$, if an innocent defendant is actually put to jail. We thus follow the general notion that most societies consider wrongful convictions to be more harmful than wrongful acquittals.[8] We further assert that prosecutor and judge, being members of society, share these preferences at large and receive a disutility of αh (a disutility of h) for any type I error (type II error). Note that $h < H$ holds as the total loss to society is the sum of all the disutilities of its individuals. Moreover, we restrict our analysis to cases where $c_J < h$ (and thus $c_P < h < \alpha h$) holds, as this implies that investigative effort is reasonable in order to avoid error costs.

With regard to the social costs of errors, the exogenous parameter α can be interpreted as the number of wrongful acquittals of guilty defendants that can be accepted in order to avoid the erroneous conviction of a single innocent person (see Tsur 2017, p. 198). From the perspective of society, this parameter thus determines the decision standard of 'beyond reasonable doubt' in criminal procedure. Now assume that μ describes the belief of the judge that the defendant is guilty, given that the case is brought to trial by the prosecutor. When eventually choosing between conviction and acquittal, and given his beliefs, the judge will convict the defendant if $-(1-\mu)\alpha h \geq -\mu h$, which allows us to derive a 'beyond reasonable doubt'-threshold as $\mu \geq \frac{\alpha}{1+\alpha}$. In our analysis, the level of effort costs warrants investigations when criminal cases are rather uncertain. In other words, when the judicial belief about

[5] This assumption follows the common notion that the prosecutorial office is designed as the primary institution for processing criminal investigations in many jurisdictions (see, among others, Griesbaum 2019, and Hodgson and Soubise 2017). Clearly, the equilibria are not affected by this assumption.

[6] One could also argue that efforts of the prosecutor and the judge are complementing each other. However, this does primarily apply to the relationship between the police force and the supervising prosecutor. Once the evidence is established, prosecutorial and judicial interpretation appear to be rather substitutes.

[7] We employ this simplifying assumption to capture the fact that the judge will never be able to fully infer the prosecutor´s effort from the case records. An alternative way to interpret the model would be that the prior γ captures the ex-ante probability of the defendant´s guilt given some observable effort of the police and the prosecutor. The studied coordination problem then arises still for the remaining inaccuracy.

[8] Givati (2011) analyzes 2006 data for OECD countries about people´s relative preference betweent type I and type II court errors. Civil law countries showed a particularly strong aversion for wrongful convictions. For Germany, about 75 percent of people regard convicting an innocent person as the more serious mistake.

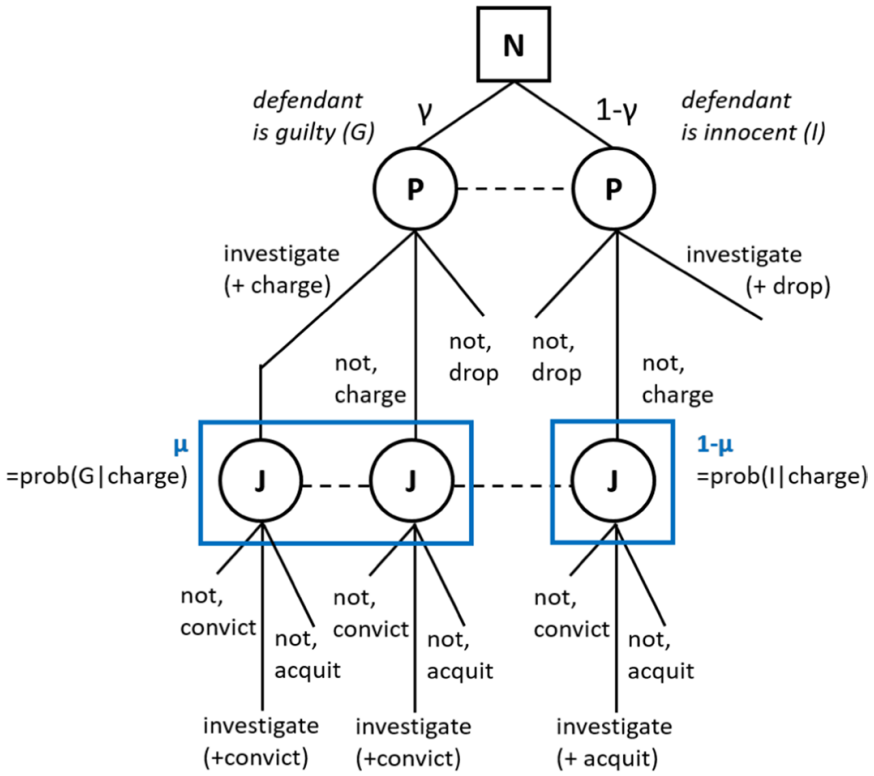

Fig. 1 Inquisitorial prosecution game

the defendant´s guilt is close to this decision standard, the judge will always prefer to further investigate the case to avoid a mistake.[9]

In addition to her interest in avoiding court errors, the prosecutor receives a disutility of L if she loses 'her case' in court. This captures reputational concerns of the prosecutor with regard to her peers, future defendants, and her superiors. As the prosecutor is assumed to follow the interests of society at large, i.e. avoiding errors, we further specify $L < h$. Overall, judges and prosecutors are assumed to be risk-neutral, and to maximize their expected utility function.[10]

The non-cooperative prosecution game consists of two stages. The game form (without payoffs) is shown in Fig. 1: The prosecutor´s decision to investigate or blindly process the case (stage 1), and the final decision by the judge if the case is brought to court (stage 2).

At the beginning, nature (N) determines the defendant´s true type, be it guilty or innocent. At stage 1, the prosecutor may then decide to investigate the case or decide about the charge without further examining the evidence. In case of investigations, she learns the true type of the defendant with certainty, which clearly makes her charge only the guilty defendants and drop the remaining cases. As an

[9] This ensures that the judge will prefer investigations to blindly convicting or acquitting the defendant when $\gamma \sim \alpha/(\alpha + 1)$ applies.

[10] This follows the notion that both agents are professional decision-makers that play this game repeatedly. Introducing risk-aversion would make both players further appreciate the certain outcome, i.e. investigating the case and revealing the truth. Thus, fewer cases will be processed without any examination.

alternative to investigations, she may either drop the case, which ends the game, or proceed blindly and move to court. At stage 2, the judge observes the charge, thus, he will update his belief μ about the defendant´s guilt. However, the judge does not know whether the prosecutor actually put effort into the investigation of the case. The judge may thus either run investigations himself, which perfectly reveals the defendant´s type and leads to a correct decision with certainty, or decide about the defendant´s guilt based on his updated beliefs.

3 Normative analysis

From the perspective of society, the criminal justice system is to maximize social welfare, that is, to encourage value-creating 'innocent' behavior and correctly impose sanctions for value-destroying 'criminal' behavior. But such "accuracy does not come for free" (Spier 2007, p. 283). Thus, a normative question has to be addressed before we can turn to the equilibrium analysis of the game: under which conditions is it desirable that P invests investigation cost into revealing the true type of the defendant? Revelation of truth is too costly if the investigation cost exceeds the expected error costs. The parameters of the enforcement system, in which P and J process a criminal case, should be such that the cost of its operation, i.e. the sum of investigation and error costs, is minimized.

In the game depicted in Fig. 1, both players have three pure strategies. Player P's strategies are a) not investigate and drop the case, b) not investigate and bring charges, and c) investigate, followed by the adequate continuation, namely drop the case if P finds out that D is not guilty, or charge if otherwise. For brevity, we denote these strategies as "drop blindly" (*n, dr*), "charge blindly" (*n, ch*), and "investigate" (*inv*). J's pure strategies are A) not investigate and convict, B) not investigate and acquit, and C) investigate, followed by the adequate judicial decision, i.e., convict if J finds out that D is guilty, and acquit if otherwise. We designate these strategies as "convict blindly" (*n, co*), "acquit blindly" (*n, ac*), and "investigate" (*inv*).

Starting from the assumption that P's cost of examining the case fall short of J's, the main research question we pursue in this paper is whether the game structure does incentivize P, but not J, to choose investigate whenever this is desirable. The equilibrium of the game would be inefficient, however, if P has incentives not to investigate even if it is desirable, or if both parties choose to investigate.

As both players have three pure strategies, nine strategy combinations exist. Table 1 indicates the outcome of the game for each strategy combination. As we focus on procedural costs, we only report the corresponding sum of effort and error costs here. Reputational concerns of the prosecutor or (dis-)utilities of the defendant are not considered.

It is clear that the strategy combination $\{(inv);(n, co)\}$ welfare dominates the combination $\{(inv);(inv)\}$, because if P has already revealed the truth, there is no benefit in additional investigations. Moreover, $\{(inv);(n, co)\}$ also dominates $\{(n, ch);(inv)\}$ by assumption. Thirdly, it dominates $\{(inv);(n, ac)\}$, because $\gamma H > 0$. As a combination of type $\{(n, dr);(x)\}$, with x being any strategy of J, yields the same social

Table 1 Outcomes and procedural costs of enforcement

		Judge		
		Investigate ***inv***	Convict blindly ***n, co***	Acquit blindly ***n, ac***
Prosecutor	Investigate ***inv***	P charges only if D is guilty; only then J investigates and decides correctly $\left(c_P + \gamma c_J\right)$	P charges only if D is guilty, then J convicts blindly, but correctly $\left(c_P\right)$	P charges only if D is guilty, then J acquits blindly and wrongly $\left(c_P + \gamma H\right)$
	Charge blindly ***n, ch***	J investigates and decides correctly $\left(c_J\right)$	All D types charged and convicted, no investigation costs $(\alpha H(1-\gamma))$	All D types charged and acquitted, no investigation costs (γH)
	Drop blindly ***n, dr***	Zero investigation cost, but guilty D types are set free (γH)		

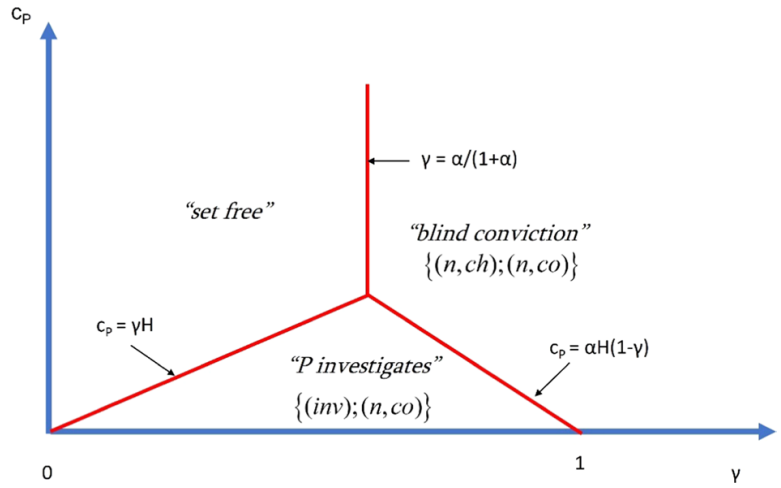

Fig. 2 Normative analysis and optimal outcomes

outcome as $\{(n, ch);(n, ac)\}$, we will use the expression *"set free"* in the following line of thought. Hence, three types of outcomes remain which must be compared:

1) P investigates, charges only if D is guilty, and J convicts blindly, $\{(inv);(n, co)\}$
2) P charges blindly, J convicts both types of D, $\{(n, ch);(n, co)\}$
3) Both types of D are released without investigations, *"set free"*

The following lemma summarizes the pair-wise comparison of the three possible outcomes (in terms of welfare) of the game.

Lemma: *(i) the strategy combination* $\{(inv);(n, co)\}$ *is strictly better than* $\{(n, ch);(n, co)\}$ *if, and only if,*$c_P < \alpha H(1-\gamma)$. *(ii) the combination* $\{(inv);(n, co)\}$ *is strictly better than "set free" if, and only if,*$c_P < \gamma H$. *(iii) the combination* $\{(n, ch);(n, co)\}$ *is strictly better than "set free" if, and only if,*$\alpha H(1-\gamma) < \gamma H \Leftrightarrow \gamma > \alpha/(1+\alpha)$.

Note that, by assumption, $c_P < H$ and $\alpha > 1$ apply. Furthermore, c_J is irrelevant for the normative analysis in the scenario $c_J > c_P > 0$. Moreover, society is welfare indifferent between "blind convictions" and "blind acquittals" if, and only if,$\gamma H = \alpha H(1-\gamma) \Leftrightarrow \gamma = \alpha/(1+\alpha)$. Figure 2 visualizes these findings.

The vertical axis shows P's investigation cost and the horizontal axis shows γ, the ex-ante probability of a given defendant D to be actually guilty. The decreasing function, $c_P = \alpha H(1-\gamma)$, captures condition i) from the *Lemma*: above this line, blind charges and convictions are preferable to investigations by the prosecutor, and below vice versa. The increasing function, $c_p = \gamma H$, depicts condition ii) from the *Lemma*: above this line, setting free all defendants is preferred to prosecutorial investigations, and below vice versa. The vertical line,$\gamma = \alpha/(1+\alpha)$, then represents condition iii). To the left of the vertical line, setting free the defendants is preferable to blind charges and convictions.

This leads to the following normative results. "Setting free" the defendant is optimal for low values of the prior and high effort costs of P, such that $\gamma < \alpha/(1+\alpha) \wedge \gamma < c_P/H$ holds. Prosecutorial investigations are socially

		Judge		
		investigate ***inv***	convict blindly ***n, co***	acquit blindly ***n, ac***
Prosecutor	investigate ***inv***	$-\gamma c_J$ $-c_p$	0 $-c_p$	$-\gamma h$ $-\gamma(h+L)-c_p$
	charge blindly ***n, ch***	$-c_J$ $-(1-\gamma)L$	$-(1-\gamma)\alpha h$ $-(1-\gamma)\alpha h$	$-\gamma h$ $-\gamma h-L$
	drop blindly ***n, dr***	$-\gamma h$ $-\gamma h$	$-\gamma h$ $-\gamma h$	$-\gamma h$ $-\gamma h$

Fig. 3 Strategic form

desirable for intermediate values of the prior and low effort costs of P, such that if $1-\frac{c_P}{\alpha H} > \gamma > \frac{c_P}{H}$ applies. Blind convictions are thus efficient for higher values of the ex-ante probability and higher effort costs, implying $\gamma > \frac{\alpha}{1+\alpha}$ and $\gamma > 1-\frac{c_P}{\alpha H}$. This normative result is straightforward: if the ex-ante probability of a guilty defendant is small, then it is optimal for the enforcement system not to investigate the case and set the defendant free. If this probability is very high, it could be optimal to convict any defendant without costly examination of the case. Only for intermediate values, costly investigations can be justified in order to make the court decision depend on the findings.

4 The prosecutor as impartial aide to the judge

In this section, we turn to the positive analysis of the depicted prosecution game in which prosecutor and judge are stylized as impartial investigators of society. We will derive Nash equilibria of the game depicted in Fig. 1 and examine whether these equilibria are also perfect Bayesian equilibria. To find all Nash equilibria, we need to set up the strategic form of the game. The strategic form of a game consists of the set of players, the set of strategy combinations, and the set of combinations of payoffs which the players attach to each strategy combination. Figure 3 illustrates the resulting 3×3 bi-matrix indicating the players' payoffs.[11]

[11] Note that this strategic form can also be derived from the following more complex game where each agent has two independent decisions: the prosecutor first decides about investigations and then about taking the case to court, and the judge decides first about investigations and then about the final verdict on the defendant´s guilt. Due to the elimination of dominated strategies, however, this game of 16×4 strategy combinations can still be reduced to the above described 3×3 bi-matrix.

A perfect Bayesian equilibrium (PBE) in this game of asymmetric information consists of the strategies $\{s_P;s_J\}$, with $s_P \in [(inv);(n,ch);(n,dr)]$ and $s_J \in [(inv);(n,co);(n,ac)]$, and the judicial beliefs $\mu = prob(G|ch)$ about the defendant´s guilt given the case is brought to court "such that, at any stage of the game, strategies are optimal given the beliefs, and the beliefs are obtained from the equilibrium strategies and observed action using Bayes´ rule" (Fudenberg and Tirole 1999, p. 326).

In this game, four candidates for a PBE in pure strategies exist contingent on the ex-ante probability of a guilty defendant. In the following, we present the results from low to high values of the a priori probability of a guilty defendant, γ.

If the ex-ante probability γ is rather low, there is always one PBE in pure strategies in which the prosecutor drops the case and prosecution ends.[12] Given the expected costs of error and a potential reputational loss, it is straightforward that the prosecutor will not proceed blindly. Moreover, the low probability of a guilty defendant then also precludes further prosecutorial investigations, given the effort costs. In the end, not taking a case to court is always rational for the prosecutor as long as the judge deems the charge meritless, thus the upper bound is $\gamma < \frac{c_J}{h}$.

Proposition 1. (i) *The strategies* $\{(n,dr);(n,ac)\}$ *form a PBE if for the judicial belief the conditions* $\mu(G|ch) < \frac{c_J}{h}$ *and* $\mu(G|ch) < \frac{\alpha}{\alpha+1}$ *apply (PBE No.1). (ii) These strategies cannot be sequentially rational if* $\gamma > \frac{c_J}{h}$ *holds.*[13]

For intermediate values of the prior γ, there are two candidates for PBE in pure strategies. Given that these two PBE coexist, also one PBE in mixed strategies can be determined.

When deciding about the individual investigation effort, each player weighs own effort costs against the expected cost of court errors. Due to $c_P < c_J$, the prosecutor will regard investigations as favorable for a wider interval of γ than the judge. If effort costs of the prosecutor, however, exceed her expected reputational damage when losing in trial, $c_P > (1-\gamma)L$, then she will still prefer to freeride on the judge´s effort. Under this condition, two pure strategy equilibria coexist when the ex-ante probability of guilt γ lies in the 'intermediate' interval $\frac{c_J}{h} < \gamma < 1 - \frac{c_J}{\alpha h}$. In either equilibrium, one player investigates, and the other player freerides. From an efficiency perspective, only the equilibrium (PBE 3) where the prosecutor looks into the case is efficient, as she bears the lowest fact-finding costs and the same court ruling is obtained.

[12] Note that the information set of the judge is not reached and that for zero probability events, any posterior μ is admissible. For any given belief, however, there exists only one optimal response by the judge.

[13] Note that two trivial Nash-equilibria, {(n, dr); (inv)} and {(n, dr); (n, ch)} exist which are always bound at least by $\gamma < \frac{c_P}{h}$, as otherwise P would prefer investigations to dropping the case. Due to $c_P < c_J$, the inequality $\frac{c_P}{h} < \frac{c_J}{h}$ holds and is consistent with Proposition 1 (ii). As the implications are similiar, i.e. the case is always dropped, we will not consider them further.

Proposition 2. *The strategies* $\{(n, ch);(inv)\}$ *form (i) a Nash Equilibrium if* $c_P > (1-\gamma)L$, $\gamma > \frac{c_J}{h}$ *and* $\gamma < 1 - \frac{c_J}{\alpha h}$ *hold. (ii) This equilibrium is a PBE given the belief* $\mu(G|ch) = \gamma$ *(PBE No. 2).*

Proposition 3. *The strategies* $\{(inv);(n, co)\}$ *form (i) a Nash Equilibrium if* $\gamma < 1 - \frac{c_P}{\alpha h}$ *and* $\gamma > \frac{c_P}{h}$ *hold. (ii) This equilibrium is a PBE given the belief* $\mu(G|ch) = 1$ *(PBE No. 3).*

In the overlap of the two pure strategy equilibria, one PBE in mixed strategies exists where the prosecutor and the judge randomize their investigation efforts. For this equilibrium to hold, the prosecutor must choose her investigative effort in a way to turn the judge indifferent between own investigations or blind convictions. The higher the probability that the prosecutor investigated the case (and thus dropped charges against innocent defendants), the more confident the judge will be about the defendant´s guilt and the more the judge´s posterior belief approaches the threshold when he is eventually indifferent between investigating and convicting without further effort. In turn, the judge must make the prosecutor indifferent between investigation and blind charges by randomizing between judicial investigative effort and blind convictions. The lower the probability of judicial investigations, the more the prosecutor will be inclined to examine that case herself given the costs of a wrongful court decision. We specify ϕ_P (ϕ_J) as the probability that the prosecutor (judge) investigates the case and derive the following proposition.

Proposition 4. *If Propositions 2 and 3 hold for given* γ*, then there exists a PBE in mixed strategies with P´s probability of effort* $\phi *_P = \frac{(1-\gamma)\alpha h - c_J}{(1-\gamma)(\alpha h - c_J)}$ *and J´s probability of effort* $\phi *_J = \frac{(1-\gamma)\alpha h - c_P}{(1-\gamma)\alpha h - (1-\gamma)L}$*, and the judicial belief* $\mu(G|ch) = 1 - \frac{c_J}{\alpha h}$ *(PBE No. 4).*

This leads to the following remarks: first, P cannot make J indifferent between investigations and blind acquittals under Propositions 2 and 3. P´s investigative effort leads to dropped cases against innocent defendants, which always increases the posterior belief μ about the defendant´s guilt. Consequently, no type II errors (wrongful acquittals) can occur in this mixed strategy outcome when the judge randomizes only between investigations and blind convictions. Second, PBE No. 2 and PBE No. 4 both require the condition $c_P > (1-\gamma)L$ to hold. That is, the prosecutor´s effort costs must exceed the ex-ante expected loss when taking the case to court and the defendant´s type is revealed. Third, a second PBE in mixed strategies can exist in which the judge randomizes between investigations and acquittal, but only for lower values of the prior, $\gamma < \frac{c_J}{h}$, and only if the equality $c_P = (1-\gamma)L$ holds. As in PBE No. 1, type II errors do occur for such low values of the prior.[14]

[14] We provide a more detailed analysis of mixed strategy outcomes in the Annex A2.

For high values of the ex-ante probability of a guilty defendant and when the prior exceeds the *reasonable doubt*-threshold, then both players do not investigate the case and all defendants are charged and convicted.

Proposition 5. *The strategies* $\{(n, ch), (n, co)\}$ *form (i) a Nash Equilibrium if* $\gamma > 1 - \frac{c_P}{\alpha h}$ *and* $\gamma > \frac{\alpha}{1+\alpha}$. *(ii) This solution is a PBE for the belief* $\mu(G|ch) = \gamma$ (*PBE No.*5).

It should be clear at this point that the determined PBE do not always coincide with the optimal outcomes from the normative analysis. This particularly applies to low and high values of the prior. The main reason is obviously that private and social incentives are not aligned: the individual disutility h of judge and prosecutor is smaller than the respective social error cost H, which results in less cases being investigated than would be socially optimal. As this is well understood in the literature (see, among others, Spier 2007), we focus on the intermediate values of the prior. This leads to the following corollary.

Corollary. *The PBE No. 3 is always efficient. PBE No. 2 is never efficient.*

For intermediate values of the ex-ante probability of guilt, $\frac{c_J}{h} < \gamma < 1 - \frac{c_J}{\alpha h}$, up to three equilibria exist and only PBE No. 3, i.e. the prosecutor investigates the case and only truly guilty defendants are charged and convicted, is socially desirable. This strategic interaction between the prosecutor and the judge can be described by the well-known battle-of-the-sexes dilemma whenever PBE 3 and PBE 4 coexist: even though both parties seek a common goal, they conflict over the distribution of the rent. In the context of this game, both agents seek to convict the guilty and acquit the innocent, but they prefer that the other party bears the investigative costs. This constitutes a free-rider dilemma. As we assume that the prosecutor shows lower effort costs, PBE 3 will be socially preferable to judicial investigations (PBE 2). PBE 3 is also favorable to the mixed strategy equilibrium (PBE 4) which gives rise to type I court errors and may also cause redundant investigations by both parties. Given the rather ideal conditions, i.e., two impartial investigators who seek to avoid court errors, efficient outcomes are not certain.

5 The opportunistic prosecutor

An obvious solution to the identified coordination problem between two strategic players is to limit one player´s choice over strategies. In the world of our prosecution game, preventing the judge from choosing *(inv)* would be a simple way to incentivize the prosecutor to investigate the case herself. For critics of the inquisitorial tradition this would be further evidence against the elevated position of the inquisitorial judge in trial. We will show in the following that such a hasty conclusion ignores the

		Judge		
		investigate ***inv***	convict blindly ***n, co***	acquit blindly ***n, ac***
Prosecutor	investigate ***inv***	$-\gamma c_J$ $\gamma V - c_p$	0 $\gamma V - c_p$	$-\gamma h$ $-\gamma L - c_p$
	charge blindly ***n, ch***	$-c_J$ $\gamma V - (1-\gamma)L$	$-(1-\gamma)\alpha h$ V	$-\gamma h$ $-L$
	drop blindly ***n, dr***	$-\gamma h$ 0	$-\gamma h$ 0	$-\gamma h$ 0

Fig. 4 Strategic form for opportunist prosecutor

relevance of the judge´s ability to examine the evidence himself as an institutional safeguard.

In the following, consider the scenario of an opportunistic prosecutor who does not care about court errors. Instead, she only weighs her prospects of winning or losing in trial when deciding about potential investigations and whether to bring charges against the defendant. For this, we assume that the opportunistic prosecutor gains a utility V when winning a case in courtroom and, as before, incurs a loss L when losing. Imagine V and L to capture the impact of trial outcome on the prosecutor, e.g., due to reputational effects or changes in self-confidence or job satisfaction. The amended strategic form is displayed in Fig. 4.

The changed preferences of the prosecutor lead to one major change of the identified equilibrium strategies: the formerly efficient equilibrium (PBE No. 3) no longer exists. Given that the judge chooses *(n, co)* and the prosecutor does not care about court errors, then, clearly, charging blindly *(n, ch)* becomes the best response to the judge convicting blindly as the condition $\gamma V - c_P < V$ always holds. The other former pure strategy equilibria of the game remain largely unaffected, although some thresholds are shifted due to the additional gain of the prosecutor when winning in court.[15] Generally, cases with a low ex-ante probability of guilt are still dropped, high probability cases are decided without investigations and the judge investigates the evidence of cases when the ex-ante probability lies in between. This result trivially implies that the coordination problem is also eliminated, though the outcome is less efficient given to higher effort costs of the judge. This is not surprising, as the judge cannot expect to freeride on the effort of an opportunist prosecutor.

Our amended model of inquisitorial prosecution thereby shows that, even for the case of an opportunistic prosecutor, this criminal justice systems still guarantees

[15] See Annex A3 for a comparison of the pure strategy equilibria.

that rather uncertain cases are investigated in equilibrium. Removing the judge´s ability to examine the case himself in such a setup would eliminate this safeguard. Without the strategy *(inv)* of the judge, cases with an ex-ante probability below the 'beyond reasonable doubt' bound, i.e. $\gamma < \alpha/(1+\alpha)$, will then always be dropped, and defendants with a higher ex-ante probability of guilt will always be convicted without examination of evidence. In other words, the legal process then exhibits no verification power of its own. Restraining the judge´s ability to investigate the case thus be may less desirable when the benevolence of the prosecutor cannot be taken for granted.

6 Policy implications

In the following, we present the implications of our inquisitorial prosecution model regarding procedural error costs and possible avenues to overcome the identified free-riding dilemma.

The first insight from our analysis is the limited occurrence of type II court errors. Plainly, court errors do not occur in the pure strategy equilibria where one of the players investigates the criminal case. This is put into perspective in the mixed strategy equilibrium where investigations occur only with a probability smaller than one and where some innocent defendants are convicted blindly. Nevertheless, only type I errors occur. This follows from the fact that the judge can only be turned indifferent between his pure strategies (*inv*) and (*n,co*), and both can never produce a false acquittal. Note that this also applies to the pure strategies equilibria PBE 2, PBE 3 and PBE 5. We thus conclude that, except for low values of the prior, $\gamma < \frac{c_J}{h}$, type II errors cannot occur in our prosecution model with two investigating agents. This is in line with the general conjecture of Adelstein and Miceli (2001, p. 49) who associate a "strong desire to punish the guilty" with inquisitorial justice systems. Moreover, our analysis shows that the alleged goal to avoid wrongful acquittals is still met when accounting for the problem of effort coordination between two investigating agents. In Christmann (2021), we show that this preference for avoiding wrongful acquittals over wrongful convictions changes at once when plea bargaining, a procedure common in adversarial criminal justice systems, is introduced into the game.

As a second implication from our model, policy makers in inquisitorial systems need to address the identified coordination problem between the prosecutor and the judge. Evidently, the two impartial investigators in criminal procedures fail with positive probability to coordinate their efforts, which leads to higher investigation costs and potential court errors. In the following, we present two policy measures that curb some of the negative effects, namely (i) adjusting the 'beyond reasonable doubt' bound or (ii) increasing reputational concerns by the prosecutor.

The 'beyond reasonable doubt' conviction threshold describes the minimal requirement for the judge´s ex-post belief about the defendant´s guilt in order to justify a conviction. This requirement increases in α, which we interprete as the number of wrongful acquittals that equal the social cost of one wrongful conviction. It is a standard assumption in the legal sciences (see, among others, Andreoni 1991,

Weinstein and Dewsbury 2006, Tsur 2017) that α is higher for more serious punishments. The analysis of our prosecution game reveals that increasing this decision standard may reduce the numbers of wrongful convictions in equilibrium but fails to reduce efforts to the efficient level.

First, an increasing α also increases the range where PBE 2 and PBE 3 and, thus, the battle-of-sexes interaction may occur.[16] For both equilibria, the upper boundary with regard to the ex-ante probability of guilt γ is shifted upward if a higher α (and thus a higher *reasonable doubt* conviction threshold) applies. This is an intuitive result as higher social costs of type I errors require a higher level of certainty about the defendant´s guilt, which enlarges the range where investigations are preferable to a blind conviction. This, at the very least, further propagates the coordination problem. Some criminal cases with a high probability of guilt that previously would have been decided efficiently without further investigation effort (PBE No. 5) are now subject to the battle-of-sexes interaction problem. Although inefficiently costly, this at least reduces the occurrence of wrongful convictions. This reasoning also applies to the mixed strategy outcome (PBE No. 4) where higher values of α increase the probability of investigation efforts by both players on the equilibrium path ($\frac{\partial \phi_J^*}{\partial \alpha} > 0$ and $\frac{\partial \phi_P^*}{\partial \alpha} > 0$). Again, this makes insufficient use of the prosecutor´s cost advantage and fails to mitigate the identified coordination problem but curbs the occurrence of type I errors. We conclude that policy makers thus may choose to raise the decision standard in criminal procedure if they primarily intend to raise equilibrium investigation efforts irrespective of cost redundancies.

The second variable of interest, prosecutor's reputational concern L, enables the policy maker to address the coordination problem directly. A prosecutor who wants to avoid losing a case that she actively choses to bring to court is clearly incentivized to make the correct choice in the first place. The inefficient equilibrium PBE No. 2 relies on the inequality $c_P > (1-\gamma)L$ to hold as the prosecutor then risks a reputational damage when moving to court to avoid certain effort costs. Evidently, sufficiently high reputational costs L eliminate the inefficient equilibrium, incentivize the prosecutor to run investigations and thereby implement the efficient PBE No. 3. Raising reputational concerns to this level, however, is risky if the policy maker is uncertain about the prosecutor´s true preferences: the above-mentioned inequality is also necessary to incentivize judicial investigations when the prosecutor is of the opportunistic type (see Fig. 4). If this inequality no longer holds, then no pure strategy equilibrium exists for intermediate values of the prior γ. This dependency of the impact of reputational costs L on judicial effort carries over to the mixed strategy outcomes: while judicial effort increases in L for the scenario of the benevolent prosecutor (in PBE No. 4), the opposite holds true when the prosecutor is opportunistic and does not care about court errors.[17] So we conclude that using reputational concerns to solve the coordination problem critically hinges on the prosecutor´s

[16] PBE 2 faces the upper bound of $\gamma < 1 - \frac{c_J}{\alpha h}$, with $\frac{\partial \gamma}{\partial \alpha} > 0$, and PBE 3 is bound by $\gamma < 1 - \frac{c_P}{\alpha h}$, with $\frac{\partial \gamma}{\partial \alpha} > 0$.

[17] We provide more details on these two mixed strategy outcomes in Annex A3.

preferences being of the benevolent type, i.e. her preferences are at least partly aligned with the interests of society.

7 Conclusions

The inquisitorial tradition regards the prosecutor as an impartial aide to the judge. In this paper, inquisitorial criminal procedures are described as a sequential game between a prosecutor and a judge who seek to convict the guilty and set free the innocent defendants. Our analysis yields three major insights.

First, a free riding dilemma unfolds between the judge and the impartial prosecutor for intermediate ex-ante probabilities of the defendant´s guilt: both investigating agents are interested in verifying the case and thus making a correct decision, but each player prefers that the other one bears the effort costs. From this theoretical perspective, it is thus unclear which outcome will prevail. This implies that it is not guaranteed that the prosecutor investigates the evidence, which would mean the lowest cost for society. It is even more problematic that, in addition to these pure strategy equilibria with certain outcomes, an equilibrium in mixed strategies exist. For this outcome, each player exerts investigative effort with a positive probability, but less than one. This generates the risk that either a doubtful criminal case is never investigated but inefficiently concluded by a 'blind' conviction, or both agents investigate which implies the duplication of efforts. In other words, wrongful convictions occur with positive probability in equilibrium when criminal cases are rather ambiguous. It is remarkable that, despite the evident coordination problem among the investigating agents, wrongful acquittals do not occur in any equilibrium except for very low ex-ante probabilities of a guilty defendant. Our theoretical results thus support a previous notion in the literature that the inquisitorial tradition is particularly driven to punish the guilty.

Second, some measures to curb the identified coordination problem are sensitive to the assumption of an impartial prosecutor who cares about avoiding court errors. If the prosecutor is incentivized to avoid losing in courts, e.g., through higher reputational concerns, this eliminates the freeriding dilemma and potentially implements the efficient pure strategy equilibrium. Even for the case of mixed strategies and positive probabilities of errors, the judge's investigation efforts increase with higher reputational concerns of the prosecutor. Unfortunately, this critically hinges on the prosecutor not being of the opportunistic type. If the prosecutor is opportunistic and does not care about court errors, such a measure will eliminate the remaining pure strategy outcome where investigations do occur in equilibrium. Even worse, judicial effort then decreases with higher reputational concerns of the prosecutor. We conclude that legal policy makers need to be aware of the preferences of the prosecutors when using reputational concerns as an incentive for prosecutorial effort.

Third, raising the burden of proof ('beyond reasonable doubt') fails to address the coordination problem between the two players and leads to the duplication of efforts, but at least reduces the probability of wrongful convictions. Furthermore, this result is not dependent on the prosecutor´s type. Even for the case of the opportunistic

prosecutor, increasing the burden of proof does incentivize the prosecutor to investigate with a higher probability in the mixed strategy outcome.

While our paper analyzes behavior in criminal procedure, its setup and implications may well carry over to other scenarios where two independent decision-makers are to verify a case, such as managerial decisions and internal audits in a company, coordination tasks between different regulators or higher and lower-level authorities, or between a firm´s compliance officer and authorities (see, e.g., Garoupa 2000, Barbieri and Konrad 2021, Fandel and Trockel 2013).

Appendix

Proofs

Proof Proposition 1

(i) The strategies $\{(n, dr);(n, ac)\}$ are always a Nash-equilibrium: if J acquits, (n, dr) is always best for P. If P drops, all J´s strategies show the same outcome. However, [(n, dr); (n, ac)] is a PBE only if out-of-equilibrium beliefs apply with $\mu < \frac{c_J}{h}$ and$\mu < \frac{\alpha}{\alpha+1}$: If J´s information set is reached, (n, ac) is only preferable to (inv) for J if$-\mu h > -c_J$, which yields $\mu < \frac{c_J}{h}$, if and $-\mu h > -(1-\mu)\alpha h$ hold, which yields$\mu < \frac{\alpha}{\alpha+1}$. This fully constitutes the PBE. (ii) It appears implausible, however, that *(n, ac)* is an equilibrium strategy for high values ofγ. Given the setup of the game, it is easy to see that the condition $\mu \geq \gamma$ must apply when the information set of the judge is reached, as the prosecutor either charged blindly or investigated the case. Given the requirements for the judicial belief of (i), we restrict our focus on the equilibrium strategies $\{(n, dr);(n, ac)\}$ on cases when $\gamma \leq \frac{c_J}{h}$ applies. This reasoning about the condition $\mu \geq \gamma$ becomes even more pronounced if we applied the tradition of Kreps and Wilson (16) to analyze off-equilibrium strategies: Consider that the players 'tremble' in their strategies with a small probability ε, implying that at each information set, the equilibrium strategy by the player is actually played with probability $1-\varepsilon$, and each of the other two off-equilibrium strategies with probability$\varepsilon/2$. This yields the judicial belief $\mu(g|ch) = \frac{\gamma\varepsilon}{\gamma\varepsilon+(1-\gamma)(\varepsilon/2)} \geq \gamma$ whenever the information set of the judge is reached. Thus, the strategies $\{(n, dr);(n, ac)\}$ cannot be sequentially rational if $\gamma > \frac{c_J}{h}$ applies.

Proof Proposition 2

(i) For investigations to be a best response by J to blind charges by P, this must be more favorable than blind acquittals,$-c_J > -\gamma h \iff \gamma > \frac{c_J}{h}$, and better than blind convictions, $-c_J > -(1-\gamma)\alpha h \Leftrightarrow \gamma < 1 - \frac{c_J}{\alpha h}$. Note that $\gamma > \frac{c_J}{h}$ implies that $\gamma > \frac{c_P}{h}$ holds for$c_J > c_P$. For a blind charge to be optimal for P, this must be preferable to dropping the case,$-(1-\gamma)L > -\gamma h \iff \gamma h > (1-\gamma)L$, and also preferable to one's own investigations,$(1-\gamma)L < c_P$. The former inequality always holds

for $c_P < \gamma h$ and$(1-\gamma)L < c_P$, as we already established $\frac{c_P}{h} < \gamma$. (ii) As P charges all defendants in equilibrium, J has to form her beliefs as $\mu = \gamma$, which was considered in (i).

Proof Proposition 3

(i) Given that P only charges the guilty defendants, for J it is always optimal to convict all charged defendants without further investigations. Given blind convictions by J, investigations are rational for P when $-c_P > -(1-\gamma)\alpha h \Leftrightarrow \gamma < 1 - \frac{c_P}{\alpha h}$ and $-c_P > -\gamma h \Leftrightarrow \gamma > \frac{c_P}{h}$. (ii) As P charges only the guilty defendants, $\mu = 1$ applies, as considered in (i).

Proof Proposition 4

The judge is indifferent between investigation and blind convictions if $-c_J = -(1-\mu)\alpha h$ holds, which yields the threshold $\mu = 1 - \frac{c_J}{\alpha h}$. We write the posterior belief of the judge as $\mu = \frac{\gamma}{\gamma + (1-\phi_P)(1-\gamma)}$. Thus, the judge is indifferent if $\mu = \frac{\gamma}{\gamma+(1-\phi_P)(1-\gamma)} = 1 - \frac{c_J}{\alpha h}$ holds, which gives $\phi *_P = \frac{(1-\gamma)\alpha h - c_J}{(1-\gamma)(\alpha h - c_J)}$. $\phi *_P \in (0;1)$ applies if$\gamma < 1 - \frac{c_J}{\alpha h}$. The prosecutor is indifferent between investigation and blind charges if $-c_P = -\phi_J(1-\gamma)L - (1-\phi_J)(1-\gamma)\alpha h$ holds. This yields $\phi *_J = \frac{(1-\gamma)\alpha h - c_P}{(1-\gamma)\alpha h - (1-\gamma)L}$. The numerator is positive for$\gamma < 1 - \frac{c_P}{\alpha h}$, and smaller than the denominator given$(1-\gamma)L < c_P$. These requirements are always met under Proposition 2 and 3.

Proof Proposition 5

(i) Given that J blindly convicts, P will respond with a blind charge if $-(1-\gamma)\alpha h > -c_P$, which gives $\gamma > 1 - \frac{c_p}{\alpha h}$, and $-(1-\gamma)\alpha h > -\gamma h \Leftrightarrow \gamma > \frac{\alpha}{1+\alpha}$. J´s best response to a blind charge is a blind conviction if $-(1-\gamma)\alpha h > -c_J$, which yields $\gamma > 1 - \frac{c_J}{\alpha h}$, and$-(1-\gamma)\alpha h > -\gamma h \iff \gamma > \frac{\alpha}{1+\alpha}$. Due to$c_J > c_P$, the inequality $\gamma > 1 - \frac{c_p}{\alpha h}$ guarantees that $\gamma > 1 - \frac{c_J}{\alpha h}$ holds.

Mixed strategy outcomes

P may choose between the pure strategies *(inv)*, *(n, ch)*, and *(n, dr)*. J may choose between the pure strategies *(inv)*, *(n, co)*, and *(n, ac)*. Given the existence of the strategy *(inv)* and $\frac{c_J}{h} < \frac{\alpha}{1+\alpha} < 1 - \frac{c_J}{\alpha h}$, P cannot be made indifferent between *(n, ch)* and *(n, dr)*, and J cannot be indifferent between *(n, ac)* and *(n, co)*. In other words, if P (or J) would be indifferent between the mentioned two pure strategies for a given γ, they would strictly prefer to choose the pure strategy (inv). Consequently, 2×2 candidates for mixed strategy equilibria remain.

In addition to Proposition 4, a second mixed strategy equilibrium exists when P mixes between *(inv)* and *(n, ch)*, and J mixes between *(inv)* and *(n, ac.)*. J is indifferent when $-\phi_P\gamma c_J - \left(1-\phi_P\right)c_J = -\gamma h$ holds, which gives $\phi_P = \frac{c_J-\gamma h}{(1-\gamma)c_J}$ and requires the condition $\gamma < \frac{c_J}{h}$ to hold. P becomes indifferent if $-c_P - (1-\phi_J)\gamma(h+L) = -\phi_J(1-\gamma)L - (1-\phi_J)(\gamma h + L)$. This only holds if $(1-\gamma)L = c_P$, and allows $\phi_J \in (0;1)$.

No mixed strategy equilibrium can exist when P mixes between *(inv)* and *(n, dr)*, and J mixes between *(inv)* and *(n, co)*. For J to become indifferent, the following condition needs to hold: $-\phi_P\gamma c_J - \left(1-\phi_P\right)\gamma h = -(1-\phi_P)\gamma h$, which cannot be fulfilled for $\phi_P > 0$. Note that, given P plays *(n, dr)*, any combination of J´s strategies would be a best response but provide identical outcomes to the pure strategy solution. We thus restrict the analysis of mixed strategy outcomes to cases where both players apply mixed strategies.

No mixed strategy equilibrium can exist when P mixes between *(inv)* and *(n, dr)*, and J mixes between *(inv)* and *(n, ac)*. For J to become indifferent, again the following condition needs to hold: $-\phi_P\gamma c_J - \left(1-\phi_P\right)\gamma h = -\gamma h \iff \phi_P\gamma\left(h-c_J\right) = 0$, which cannot be fulfilled for $\phi_P > 0$ and $h > c_J$.

Comparison of equilibria

Equilibrium	Impartial prosecutor	Opportunistic prosecutor
PBE No. 1	($\gamma > \frac{c_J}{h}$ violates sequential rationality)	($\gamma > \frac{c_J}{h}$ violates sequential rationality)
PBE No. 2	$c_P > (1-\gamma)L$; $\gamma > \frac{c_J}{h}$;$\gamma < 1 - \frac{c_J}{\alpha h}$	$\gamma > \frac{L}{V+L}$;$c_P > (1-\gamma)L$; $\gamma > \frac{c_J}{h}$;$\gamma < 1 - \frac{c_J}{\alpha h}$
PBE No. 3	$\gamma < 1 - \frac{c_P}{\alpha h}$; $\gamma > \frac{c_P}{h}$	*(does not exist)*
PBE No. 4	$\phi *_P = \frac{(1-\gamma)\alpha h - c_J}{(1-\gamma)(\alpha h - c_J)}$ $\phi *_J = \frac{(1-\gamma)\alpha h - c_P}{(1-\gamma)\alpha h - (1-\gamma)L}$ $c_P > (1-\gamma)L; \gamma < 1 - \frac{c_J}{\alpha h}$	$\phi *_P = \frac{(1-\gamma)\alpha h - c_J}{(1-\gamma)(\alpha h - c_J)}$ $\phi *_J = \frac{(1-\gamma)V + c_P}{(1-\gamma)(V+L)}$ $c_P < (1-\gamma)L; \gamma < 1 - \frac{c_J}{\alpha h}$
PBE No. 5	$\gamma > 1 - \frac{c_P}{\alpha h}$; $\gamma > \frac{\alpha}{1+\alpha}$	$\gamma > 1 - \frac{c_J}{\alpha h}$; $\gamma > \frac{\alpha}{1+\alpha}$

Acknowledgments We thank Andreas Polk, Josh Gomersall, the participants of the annual conference of the German Law and Economics Association 2021 and three anonymous reviewers for critical scrutiny, valuable comments and helpful suggestions.

Funding The authors did not receive support from any organization for the submitted work.

Declarations

Conflict of interest The authors have no relevant financial or non-financial interests to disclose.

References

Adelstein, R., & Miceli, T. (2001). Toward a comparative economics of plea bargaining. *European Journal of Law and Economics, 11*, 47–67.

Andreoni, J. (1991). Reasonable doubt and the optimal magnitude of fines: Should the penalty fit the crime? *The RAND Journal of Economics, 22*, 385–395.

Barbieri, S., & Konrad, K. (2021). Overzealous rule makers. *Journal of Law and Economics, 64*, 341–365.

Christmann, R. (2021). Plea bargaining and investigation effort. Inquisitorial criminal procedure as a three-player game. Research paper No. 9, Leibniz FH.

Dharmapala, D., Garoupa, N., & Richard, H. M. (2013). Do Exclusionary Rules Convict the Innocent? In T. Miceli & M. Baker (Eds.), *Research handbook on economic models of law.* Edward Elgar Publishing.

Fandel, G., & Trockel, J. (2013). Avoiding non-optimal management decisions by applying a three-person inspection game. *European Journal of Operational Research, 226*, 85–93.

Fudenberg, D., & Tirole, J. (1999). *Game Theory*. MIT Press.

Garoupa, N. (2000). Corporate criminal law and organization incentives: A managerial perspective. *Managerial and Decision Economics, 21*, 243–252.

Garoupa, N. (2012). The economics of prosecutors. In A. Harel & K. Hylton (Eds.), *Research handbook on the economics of criminal law.* Edward Elgar Publishing.

Givati, Y. (2011). The comparative law and economics of plea bargaining. Discussion paper No. 39, Harvard Law School.

Griesbaum, R., (2019). In: Hannich, R. (ed.) *Karlsruher Kommentar zur Strafprozessordnung*, Band 1, §163 Rn. 2–4.

Harris, J. (1970). On the economics of law and order. *Journal of Political Economy, 78*, 165–174.

Hodgson, J., & Laurène, S. (2017). Prosecution in France. In T. Allen (Ed.), *Oxford handbooks online.* Oxford University Press.

Kaye, D. (2001). The error of equal error rates. *Law, Probability and Risk, 1*, 3–8.

Kim, C. (2013). Adversarial and inquisitorial procedures with information acquisition. *Journal of Law, Economics & Organization, 30*, 767–803.

Kreps, D., & Wilson, R. (1982). Sequential equilibria. *Econometrica, 50*, 863–894.

Rizzolli, M. (2019). Type-I and Type-II errors. In A. Marciano & G. Ramello (Eds.), *Encyclopedia of law and economics.* Springer.

Spier, K. (2007). Litigation. In M. Polinsky & S. Shavell (Eds.), *Handbook of law and economics.* North Holland.

Tirole, J., & Dewatripont, M. (1999). Advocates. *Journal of Political Economy, 107*, 1–39.

Tsur, Y. (2017). Bound reasonable doubt: Implications for plea bargaining. *European Journal of Law and Economics, 44*, 197–216.

Tullock, G. (1975). On the efficient organization of trials. *Kyklos, 28*(4), 745–762.

Tullock, G. (1994). Court errors. *European Journal of Law and Economics, 1*, 9–21.

Weinstein, J., & Dewsbury, I. (2006). Comment on the meaning of 'proof beyond reasonable doubt.' *Law, Probability and Risk, 5*, 167–173.

6. Plea Bargaining and Investigation Effort: Inquisitorial Criminal Procedure as a Three-Player Game.

(European Journal of Law & Economics, forthcoming)

European Journal of Law and Economics
https://doi.org/10.1007/s10657-023-09782-9

Plea bargaining and investigation effort: inquisitorial criminal procedure as a three-player game

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Accepted: 2 October 2023

Abstract

This paper contributes to the question whether plea bargaining is compatible with the inquisitorial tradition. We stylize inquisitorial criminal procedure as a sequential game with two impartial investigators, judge and prosecutor. Both agents are subject to private investigation costs and seek a correct decision over a defendant of uncertain guilt. Our analysis shows that the introduction of plea deals in courtroom helps to overcome the problem of effort coordination between the two agents. Moreover, we demonstrate that the introduction of plea deals reduces the number of wrongful convictions, but this comes at the cost of some guilty defendants getting away unpunished. Our results are robust to small decision errors by the players and attorney moral hazard. We further consider the implications of imperfect verification skills by judges, different timing of deals, or prosecutors who just seek to maximize convictions and guilty pleas.

Keywords Screening · Free-riding · Litigation · Court errors

JEL Classification K14 · K41 · D82

We are thankful for helpful comments and suggestions by the participants of the Annual Conference of the German Law and Economics Association 2022, the Economic Analysis of Litigation Workshop 2021, the Conference of the Italian Economic Association 2021 and the LIEN lecture in Paris-Nanterre 2021. Furthermore, the paper also greatly benefitted from discussions among colleagues and fellow researchers at the Leibniz FH and at the economics faculty of the Otto-von-Guericke University, and from the helpful feedback of three anonymous reviewers.

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1 Introduction

The plea bargain, a legal practice where the defendant pleads guilty in exchange for a reduced punishment, is often regarded as alien to the inquisitorial law tradition.[1] In contrast to adversarial procedures where mainly the parties are responsible for presenting evidence, the inquisitorial trial is primarily run by the judge as the neutral investigator and decision-maker. The judge is obliged to establish the truth. In this perspective, the determination of guilt is not at the discretion of the prosecutor or the defendant and thus cannot be part of any bargain. However, it cannot be denied that plea bargaining has become common in legal justice systems around the world (see, e.g., Hodgson, 2015 for an overview). Law & economics scholars have identified important features of plea bargaining, such as lower procedural costs of enforcement and less uncertainty about the outcome of trial. Most remarkably, plea bargaining serves as a screening mechanism to sort the guilty from the innocent defendants (see Lewisch, 2000 for an overview).

The case of Germany, a country that was once called "the land without plea bargaining" (Langbein, 1979) with a strong inquisitorial tradition, is particularly illustrative for this ongoing debate.[2] Klaus Tolksdorf, the former president of the German Federal Court of Justice, called the increasing use of plea deals as "devastating for the reputation of justice" (Frankfurter Allgemeine Zeitung, 2009). Other scholars claim that 'informal' deals will promote guilty pleas by defendants without sufficient evidence (see Jahn & Kudlich, 2016). A recent government review of plea bargaining in Germany did reveal frequent violations of the legal requirements due to 'informal' deals, a lack of oversight by prosecutors and judges, and degraded safeguards for the defendant (see Altenhain et al., 2020).

In this paper, we study (i) the impact of plea bargaining on the coordination of investigative effort between judge and prosecutor and (ii) its capability to screen for guilty defendants in the inquisitorial justice system. While many comparative law and economic scholars focus on the judge as the single decision-maker in the inquisitorial tradition, we follow Christmann and Kirstein (2022) who stylize inquisitorial procedures as a sequential game with two impartial investigators, judge and prosecutor. In their model, the two agents are engaged in a "battle-of-the-sexes"-dilemma as they try to coordinate their investigative efforts. Christmann and Kirstein (2022) demonstrate that if no agent always chooses investigative effort, a mixed strategy equilibrium still exists where no wrongful acquittals occur, but some innocent defendants are wrongfully convicted. In this paper, we will take the analysis

[1] Scholars in inquisitorial legal systems argue that any (negotiated) punishment requires the determination of guilt by the state, and this determination needs to be justified by the evaluation of the evidence of the case ('nulla poena sine culpa'). Consequently, any guilty plea that saves court resources due to avoided investigations or a reduction in the defendant´s rights is regarded as a violation of this principle (see, e.g., Landau 2011).

[2] Many inquisitorial countries, such as France, have introduced plea deals alongside other adversarial elements into their procedures. Such deals typically occur before trial to save resources, but these agreements are later validated by the judge. In Germany, the legislator finally recognized the practice of plea offers in 2009 but also attempted not to interfere with the inquisitorial doctrine, i.e. plea deals are to be negotiated during trial (§257c StPO), and the agreement does not relieve the judge of his obligation to examine the evidence.

to the next level and introduce the defendant as the third player to this strategic interaction. Furthermore, we will allow the judge to initiate a plea offer to end the game before court proceedings commence. Our analysis shows that the introduction of plea deals helps to resolve the above-mentioned problem of effort coordination between the two investigating agents. More specifically, we find that a (trembling-hand) perfect equilibrium can exist that achieves complete separation between guilty and innocent defendants if and only if the deal offer is made after the initial investigations by the prosecutor but before court proceedings start. This is remarkable compared to the typically semi-separating equilibria in the literature on adversarial plea bargaining (see Baker & Mezzetti, 2001). In contrast to the widespread concerns in the legal debate, and again distinct from Christmann and Kirstein (2022), we also demonstrate that plea bargaining reduces the frequency of wrongful *convictions* (type I errors) in inquisitorial procedures. This paper particularly contributes to the presumption of Adelstein and Miceli (2001) who characterized the adversarial system by its aversion to wrongful conviction and, for the inquisitorial system, presumed a strong desire to punish the guilty defendants. Our findings thus substantiate their presumption and indicate a systemic shift in the avoidance of courts errors when plea deals are introduced in inquisitorial procedures. Outside the field of criminal law, our game-theoretic model also applies to other legal disputes and bargaining between a state authority and a defendant, such as tax law cases and leniency programs in antitrust proceedings.

The paper is organized as follows: in Sect. 2, we provide a review of the related literature and introduce our model setup in Sect. 3. Section 4 then provides an analysis of the identified sequential equilibria of the game. We discuss our main findings and policy implications in Sect. 5 and consider some extensions and caveats to plea bargaining in Sect. 6. Section 7 concludes.

2 Related literature

Researchers have shown a strong interest in the institution of plea bargaining both due to its strong prevalence particularly in the U.S. criminal justice system and its obvious resemblance to pre-trial settlements in civil procedure.[3] From the law and economics discipline, plea bargaining has often received a rather favorable, "upbeat assessment" (Garoupa & Stephen, 2008, p. 326). While one major strand of research regards plea bargaining as a pricing device for crime (see, among many others, Landes, 1971, Adelstein, 1979, Easterbrook, 2013, Covey, 2016), this paper contributes particularly to the large literature that studies plea bargaining as a screening mechanism.

Since the landmark article of Grossman and Katz (1983) and later refinements by Reinganum (1988) and Baker and Mezzetti (2001), the plea offer has been interpreted as a strategy for the prosecutor to better distinguish the guilty from the

[3] Despite obvious similarities through the negotiations between opposing legal parties, plea bargaining clearly differs from civil proceedings. For example, the prosecutor is representing the state and has access to exclusive resources, and the subject-matter is primarily a risk only to the defendant, as the court ruling could lead to monetary sanctions or imprisonment.

innocent defendants. Plea bargaining may thus save scarce prosecutorial resources. Researchers have particularly focused on the extent of prosecutorial discretion, the risk of wrongful guilty pleas and the standard of proof. Reinganum (1988) showed that a large discretion of the prosecutor to extend case-specific bargains to defendants is particularly desirable when previous screening by the police force is rather poor. Similarly, Bjerk (2021) points out that plea deals that do not separate between the guilty and the innocent are justified if the ex-ante probability of guilt is high. Gazal-Ayal and Thor (2012) find evidence that the common fear about innocent defendants pleading guilty is not justified empirically, but still suggest limitations on plea discounts to maintain proper incentives. In this regard, Mungan and Klick (2016) propose large exoneree compensations to further limit the risk of wrongful convictions. Tsur (2017) demonstrated that all plea bargaining equilibria in the interaction of a benevolent prosecutor with strategic defendants and juries fit the principle of equality before the law. Many researchers have yet questioned the underlying model assumptions, such as benevolent preferences of the prosecutor (see, e.g. Bibas, 2004; Garoupa, 2012), her ability to interpret new information in an unbiased manner (see, e.g. Burke, 2007; Christmann, 2021) and risk-neutral behavior by the defendants (see Kobayashi & Lott, 1996). In the words of Easterbrook (1992), however, much of the criticism has to be attributed to underlying imperfections of the trial in general.

Plea bargaining appears to be deeply rooted in adversarial criminal justice systems.[4] According to scholars of comparative criminal law, the strengths of the adversarial system are the superior incentives of the litigants to reveal private information to the court (see, among others, Tirole and Detrawipont, 1999, Froeb & Kobayashi, 2001; Spier, 2007, pp. 313). For example, the information asymmetry between the informed defendant and the uninformed prosecutor will continuously diminish in the course of the proceedings, but litigation expenditures increase. Given this trade-off between accuracy of the deal and cost-savings, both parties are motivated to find the best timing for the plea bargain (see Garoupa & Stephen, 2008). Many researchers argue that incentives for information collection in inquisitorial legal systems are rather low: Kim (2013) points out that, in contrast to the parties themselves, the effort of the uninformed inquisitorial judge has to be less effective in extracting truthful information. This induces more decision errors by the court. The incentive problem becomes even more pronounced when one acknowledges that the inquisitorial system relies on two benevolent representatives of society, the judge as inquisitor and the prosecutor as his aide. Considering judge and prosecutor as economic agents, Christmann and Kirstein (2022) show that coordination problems emerge as each of the two agents prefers to freeride on the other one´s effort, although a higher standard of proof can partly mitigate this inefficiency. Emons and Fluet (2009) find that parties are also more tempted to distort the evidence in the inquisitorial setup than in an adversarial hearing.

[4] In addition to its widespread use in the US, two out of three pleas in England and Wales involve a guilty plea by the defendant (see UK Ministry of Justice 2019). However, mere guilty pleas may not be identical to real plea bargaining between the parties (see comments by Garoupa and Stephen 2008).

Despite these disparities in legal doctrines, plea bargaining has become common in many inquisitorial justice systems (for an overview, see Hodgson, 2015). Several legal scholars resent this development and regard such bargains as not compatible with the inquisitorial law tradition, as the criminal case is not at the discretion of the parties and the process of revealing the truth is to be governed by the impartial judge (see, among others, Wohlers, 2010; Landau, 2011; Rönnau, 2018). In a comparative law setting, Adelstein and Miceli (2001) attempt to capture the traditional differences between the two paradigms by assuming that efficiency for adversarial systems is interpreted as a strong aversion to wrongful convictions while efficiency for the inquisitorial tradition implies a strong desire for convicting the guilty defendants. The authors thus conclude that plea bargaining is welfare-enhancing only for adversarial systems, as sentence discounts through bargains spare the guilty defendants in order to reduce the social costs of wrongful convictions. Givati (2011), however, rejects the assumptions of their model and argues that, given the higher crime rate in common law countries and thus limited budgets for prosecution, plea bargaining is best suited to punish the guilty.

Among some insightful country studies, the cases of Italy and Germany are particularly illustrative:

Despite its inquisitorial heritage, Italy early adopted major reforms towards adversarial procedures, such as plea bargaining.[5] For smaller offenses, prosecutor and defendant can negotiate a plea deal under the supervision of the judge. Moreover, the defendant is always entitled to ask the judge directly for a reduced sentence without the agreement of the prosecutor. However, the prosecutor is still required to conduct preliminary examinations of the evidence beforehand, and the judge is obliged to review the requirements of the plea bargain afterwards. For Boari and Fiorentini (2001), this Italian approach has failed because it made insufficient use of the strength of plea bargaining, such as resource savings, and did not achieve a sufficient transition in the legal culture of the judiciary. Frommann (2009) is more positive about the reform and argues that the chosen approach prevents the prosecutor from overcharging or justifying a deal offer on arbitrary grounds, and provides sufficient independence for the judge. The author also regards the Italian way to be particularly similar to the approach of the German legislator.

Distinct from Italy, the practice of plea deals (‘*Absprachen’*) in Germany had developed more informally and in very differing ways throughout courtrooms until the German legislator enacted the *‘Law on Agreements in Criminal Proceedings’* in 2009. As part of the official government review, Altenhain et al. (2020) present a large comprehensive survey and review of case records on the current legal practice under the new law. The authors find that about 15 percent of all criminal cases (advocates report higher numbers, between 26 and 33 percent) are concluded by plea deals, and that the average reduction in punishment was stated to be about 20 to 25 percent. For the vast majority of examined cases, plea bargaining occurred prior to the hearing of evidence. Moreover, plea deals were usually proposed by the judge or,

[5] Although the Italian Code of Penal Procedure underwent a major reform to adversarial procedures including plea deals in 1988, Parlato (2012) sees the Italian systems still as a mixture of adversarial and inquisitorial elements.

with a higher rate of success, by the defendant, but only rarely by prosecutors.[6] The survey also revealed some worrisome findings: interviews indicated that some guilty pleas were made by defendants after the judge had threatened the defendant with the prospect of a much higher punishment if the deal offer was turned down (so-called '*Sanktionsschere*'). Moreover, defendants often waivered their right to appeal as part of the bargain. For the authors, it is also notable that the prosecutorial office rarely requested an official review of successful plea bargains, which may not be in line with their role as "guardians of the rule of law" (Altenhain et al., 2020, p.537).

This article also touches upon other fields of research outside the institution of plea bargaining: there is, for instance, a comprehensive literature on court accuracy, evidence production and the verification of facts in court (see, among others, Miceli, 1990, Kaplow, 1994, Tullock, 1994, Yilankaya, 2002, Gennaioli, 2013, Christmann, 2014). This literature specifies the probability of correct or wrongful judicial decisions, either endogenously or exogenously, and then studies the sensitivity (or performance) of legal institutions to different types of court errors. Moreover, there is a continuous debate about mandatory or selective prosecution in criminal proceedings (see, e.g., Garoupa, 2009 for an overview).[7] While we allow the prosecutor to drop charges in our model when preliminary evidence is insufficient, our main concern is the management of criminal cases that a rational, benevolent decision-maker would choose to investigate under both principles.

3 The inquisitorial prosecution model

This model builds on the two-player prosecution game by Christmann and Kirstein (2022) in which the authors study free-riding behavior between the judge (J) and the prosecutor (P) in the inquisitorial justice system. We introduce a third player to the game, the defendant (D), who may plead guilty to avoid a full trial. Thus, we study the impact of plea bargaining on the equilibrium strategies of the three players in the inquisitorial prosecution game.

The defendant is one of two types, as he is either guilty of a crime (g) or he is innocent (i). The type of the defendant is specified by nature (N) at the beginning of the game and let γ be the ex-ante probability of a guilty defendant.[8] While the ex-ante probability is assumed common knowledge, only the defendant knows his true type. In this game, the defendant is accused of having committed a crime which is subject

[6] §257c of the German code of criminal procedure specifies that it is the judge that announces the possible terms of the plea offer in court. Some legal scholars of the inquisitorial tradition criticize this as "unleashing" of the judge (Schünemann, 2007, p. 950).

[7] The so-called legality principle imposes mandatory prosecution of criminal cases while the opportunity principle grants some discretion to the prosecutor not to pursue criminal charges (see Lewisch 2000, IBA 2021).

[8] The ex-ante probability of a guilty defendant describes the a-priori probability distribution that players have over the defendant´s type. It can be interpreted as the level of initial suspicion that a particular person committed the offence, and this relies on the police force to correctly identify and apprehend suspects. This follows the standard approach in many screening models (see, e.g., Baker and Mezzetti, 2001). It must be distinguished from models on evidence production in court (such as Miceli, 1990) where the initial level of evidence is often stylized as a random variable which is conditional on the defendant´s type.

to the punishment F. Think of the value F as society´s response to the alleged unlawful behavior and assume F increases with the severity of the crime. Thus, if the defendant is eventually convicted and sentenced, he receives the utility $-F$, otherwise his utility is set to zero. To avoid this punishment, the defendant may give in to a plea deal Σ at an earlier stage, and thus accept the bargained sentence without further court procedures. Following this logic, we believe that a plea deal may offer some "discount" (Lewisch, 2000, p. 250) on the sentence to the defendant but it can never exceed the punishment F defined by law.[9] Nevertheless, the deal offer has to exceed the mere cost of trial T, otherwise proving one´s innocence in court would never be rational. Thus, we restrict our analysis to $T < \Sigma \leq \mathrm{F}$.

Society wants the guilty defendants to be convicted and punished while the innocent defendants should be acquitted and set free. Wrongful convictions (type I error) and wrongful acquittals (type II error) thus deviate from the goals of society, and should be avoided. We assume that the prosecutor and the judge, as 'impartial investigators' of society, are motivated to avoid such court errors. If a truly guilty defendant is wrongfully acquitted, then each agent receives a disutility of H. If a truly innocent individual is sent to prison, then prosecutor and judge receive the disutility αH, with $\alpha > 1$. Image the value α to be the number of wrongful acquittals of guilty defendants that are acceptable for society in order to avoid the wrongful conviction of a single innocent individual (see Tsur, 2017, p. 198). We thus follow the general notion that wrongful convictions are regarded as more harmful by liberal societies. Consider the probability μ to be the belief of the judge upon trial that the defendant is actually guilty, then the judge will convict the defendant if $-(1-\mu)\alpha H \geq -\mu H$ applies. This gives the court´s decision standard ('*beyond reasonable doubt*')[10] for a conviction as $\mu \geq \frac{\alpha}{1+\alpha}$.

The prosecutor and the judge seek to determine the true type of the defendant. For this, each of the two players may investigate the evidence of the case. For simplicity, we assume that investigations perfectly reveal the defendant´s true type but produce effort costs c_P for the prosecutor and c_J for the judge. As we focus on effort coordination in this paper, we exclude cases where criminal investigations can never be favorable, i.e. effort costs in our model are assumed to be lower than error costs. Given that the prosecutorial office has superior resources and closely cooperates with the police, we assume that that the prosecutor can investigate the case at lower costs compared to the judge. This captures the widely held perception of the prosecutorial office as the chief investigator (so-called '*Herrin des Ermittlungsverfahrens*')[11] in inquisitorial criminal systems. These specifications yield $c_P < c_J < H < \alpha H$. If the

[9] The study by Altenhain et al., (2020, p. 525) reports that plea bargains in Germany show an average discount of about 25 percent to the full trial outcome.

[10] While the expression '*beyond reasonable doubt*' is rooted in the adversarial doctrine, the presented rationale carries over to the inquisitorial tradition. Moreover, the German Federal Court of Justice repeatedly required the judicial evaluation of the evidence to achieve a sufficient level of certainty which, in the wording of the court, precludes reasonable doubts (see BGH 01.07.2008, 1 StR 654/07). We excluded $\alpha < 1$, as this would allow convictions although innocence is more likely than guilt.

[11] In German criminal procedure, the prosecutorial office clearly dominates the investigations prior to the charge, monitors the police force and even supervises the adherence to the law during trial. Its famous nickname is also used by the Federal Court of Justice (see, e.g., BGH II BGs 335/99 [2009]).

case actually moves to court, then all players bear additional trial costs T. However, whether the case was already investigated by the prosecutor or simply passed on to court without examination remains the private information of the prosecutor.[12] Note that we treat investigation efforts of prosecutor and judge as substitutes here.[13] Furthermore, we assume that the prosecutor bears a reputational loss L when she loses a case that she chose to bring to court.[14] As we assumed judge and prosecutor to be primarily driven by society´s desire to avoid court errors, we specify $L < H$. All players are assumed to be risk-neutral,[15] and they maximize their expected utility.

The non-cooperative game consists of three stages, as illustrated by Fig. 1: The decision of the prosecutor (stage 1), the potential plea deal (stage 2), and the judge who makes the final decision (stage 3).

First, nature determines whether the defendant is truly guilty or innocent. At stage 1, the prosecutor can either decide to investigate the case (which will make her charge only the guilty defendants and drop charges against the innocent ones), she may drop the case, or she may charge the defendant "blindly" without any examination of evidence. At stage 2, the judge observes that the prosecutor selected the case for trial, updating his beliefs about the defendant´s guilt. He then offers a plea deal to the defendant, which can either be accepted and the game ends, or the deal is rejected by the defendant and court proceedings commence. At stage 3, the judge observes the failure of plea bargaining, and again updates his beliefs according to Bayes´ rule. He may then either investigate the case himself, which always leads to a correct decision, or decide about conviction or acquittal based on his beliefs about the defendant´s guilt.

4 Equilibria analysis

4.1 Equilibria in pure strategies

In the following, we study the strategic interaction between the two enforcement agents, judge and prosecutor, and the defendant in inquisitorial criminal procedure when plea bargaining is possible. We develop the strategic form of the game to identify all Nash Equilibria (NE), and then apply the narrower concept of Sequential Equilibrium (SE) to verify whether these equilibria are also plausible given the

[12] While an agent will never declare that she has not examined the evidence of the case, it will be difficult to assess her true investigative effort only from the written report in the case file (the 'dossier') that is passed on to the judge.

[13] Although the agents´ effort can be considered as complements, we think that this applies more to the relationship between the police investigation and the prosecutorial office, but less so during trial where both parties are to present their evidence to the court. Note that the studied problem of effort coordination requires the agents´ efforts to be substitutes at least to a certain extent.

[14] Note that the inquisitorial principle of compulsory prosecution for capital offences only requires the prosecutor to move to court if she regards the evidence to be sufficient to support the charge. In the world of our model, this still implies that she can decide to drop the case if the probability of guilt is rather low.

[15] For risk-aversion to make a difference in our setup, the prosecutor must be non-benevolent (chapter 6.2) and verifiability by the judge must be imperfect (chapter 6.3). Otherwise, at least one equilibrium exists for intermediate values of the prior where there is no uncertainty about the court´s decision.

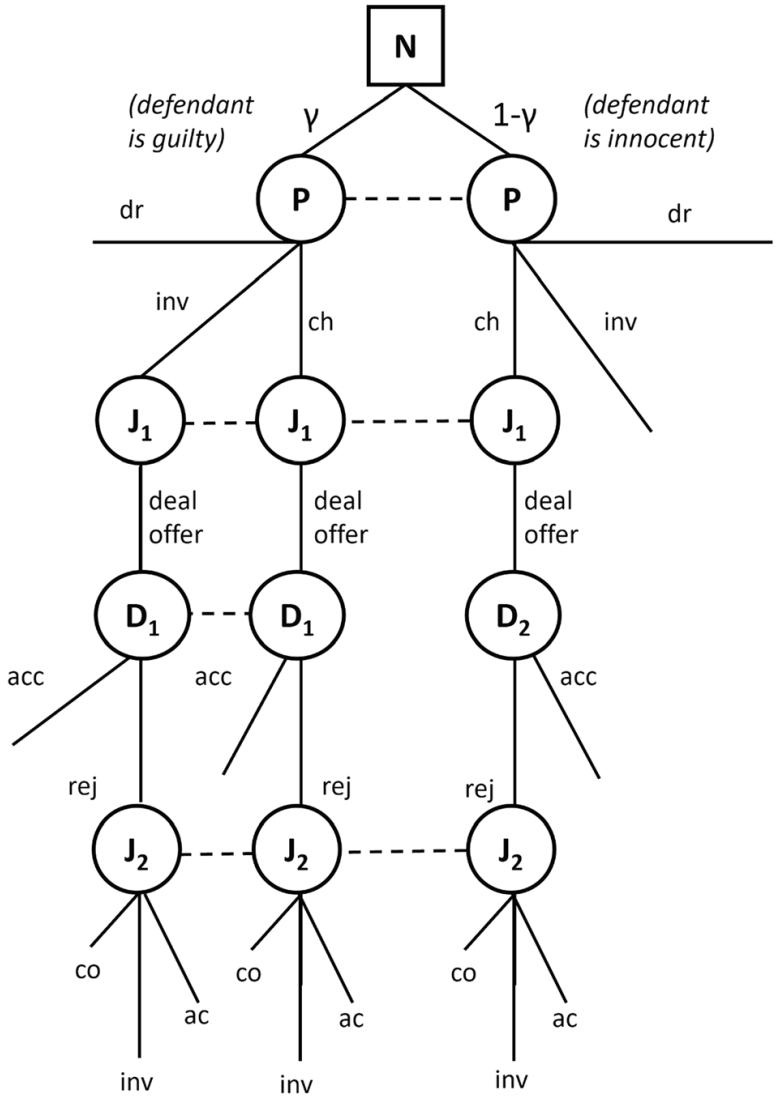

Fig. 1 Inquisitorial prosecution game with plea deals

timing of the game.[16] For the sake of brevity, we use the following notation for the described actions: investigate case (*inv*), charge defendant (*ch*), drop case (*dr*), convict defendant (*co*), acquit defendant (*ac*), reject deal (*rej*) and accept deal (*acc*).

A Sequential Equilibrium (SE) in this game of asymmetric information consists of the strategy profile $\sigma* = \{s_P, s_J, s_D\}$, with $s_P \in [(inv); (ch); (dr)]$, $s_J \in [(\Sigma, inv); (\Sigma, co); (\Sigma, ac)]$ and $s_D \in [(rej, rej); (rej, acc); (acc, rej); (acc, acc)]$, and the judicial beliefs[17] $\mu_1(g|ch)$ and $\mu_2(g|ch \cap rej)$, when the assessment

[16] Note that this strategic form can also be derived from the following more complex game where prosecutor and judge have two independent decisions: the prosecutor first decides about investigations and then about taking the case to court, and the judge decides first about investigations and then about the final verdict on the defendant´s guilt. Due to the elimination of dominated strategies, however, this complex game of 16×4×4 strategy combinations can be reduced to the applied 3×3×4 tri-matrix. See Appendix 1 for the strategic form of the game.

[17] For sake of brevity, we will not report beliefs of the guilty defendant at decision node D_1. Whether the prosecutor investigated the case has no impact on the guilty defendant´s payoffs in the further course of the game, and thus any belief [0;1] is always admitted.

$(\sigma*, \mu_1*, \mu_2*)$ is sequentially rational and consistent for every information set. This implies that each "player´s own strategy is optimal starting from *every* point in the [game] tree" (Kreps & Wilson, 1982, p. 863).[18]

In this game, three types of SE in pure strategies exist: (i) the prosecutor drops all charges, (ii) the prosecutor investigates all cases, she charges only the guilty defendants who then accept a plea deal, and (iii) all defendants are charged and accept a plea bargain. All pure strategy SE require no further restrictions on plea deals Σ, and types (ii) and (iii) always adhere to the '*reasonable doubt'*-bound.[19]

For low values of the prior γ, there exist two SE in pure strategies where the prosecutor drops the case without further investigations. For these equilibria to hold, the probability of a guilty defendant must be so low that investigating the case or proceeding blindly to court is not favorable for the prosecutor. For these cases, the ex-ante probability of guilt does not meet the decision standard for a conviction ($\gamma < \frac{\alpha}{1+\alpha}$).[20]

Proposition 1.1 *The strategies* $\{(dr); (\Sigma, ac); (rej, rej)\}$ *are (i) a NE which constitutes (ii) a SE if also* $\gamma < \frac{\alpha}{2+\alpha}$, $\gamma < \frac{c_j}{2H-c_j}$ *and beliefs* $\mu_1 = \frac{\gamma}{(1/2)+(1/2)\gamma}$ *and* $\mu_2 = \frac{\gamma}{(1/2)+(1/2)\gamma}$ *apply.*

Proposition 1.2 *The strategies* $\{(dr); (\Sigma, co); (acc, acc)\}$ *are (i) a NE if* $\frac{c_p}{H} > \gamma$ *and* $\frac{\alpha}{1+\alpha} > \gamma$, *and constitute (ii) a SE only if* $\frac{c_p}{H} > \gamma > \frac{\alpha H - c_j}{\alpha H + c_j}$ *and* $\frac{\alpha}{1+\alpha} > \gamma > \frac{\alpha}{2+\alpha}$ *and beliefs* $\mu_1 = \frac{\gamma}{(1/2)+(1/2)\gamma}$ *and* $\mu_2 = \frac{\gamma}{(1/2)+(1/2)\gamma}$ *apply.*

Proof See Appendix 2.

For intermediate probabilities of guilt, two SE in pure strategies exist where the Prosecutor investigates the case and charges the guilty defendants, guilty defendants accept the plea deal, and the judge would convict all guilty defendant if trial occurred. Clearly, the investigating prosecutor would only charge the guilty defendants who then always accept the plea deal when they expect a conviction in court. The decision of the innocent defendants about the plea deal (D_2) lies off the equilibrium path, and trial (J_2) never occurs. The equilibrium strategy of the judge then hinges on his beliefs about the probability of a guilty defendant when a case somehow does reach court, i.e. if the prosecutor or the defendant 'tremble' and deviate from the optimal strategy with small probability. In one SE, the judge always convicts, *(co)*, and all defendants accept plea deals *(acc, acc)*. This equilibrium builds on the insight that the judge can safely rely on a high probability of guilty defendants if the case reaches court: it is simply less likely that two errors occur simultaneously, i.e. an innocent defendant is actually charged and also rejects the deal by mistake.

[18] The widespread concept of the Perfect Bayesian Equilibrium imposes little restrictions on rational beliefs about zero-probability events (see Fudenberg and Tirole, 1999, pp. 321). We apply the more refined concept of Sequential Equilibria here to identify credible outcomes.

[19] We do not specify judicial preferences for strict or lenient plea deals in the game. However, all pure strategy SE are compatible with strict plea offers ($F = \Sigma$). In other words, if this is the socially optimal punishment or sentence discounts lead to judicial disutility, $F = \Sigma$ can be enforced.

[20] There is also a less interesting mixed-strategy equilibrium where P always drops, J randomizes between investigations and acquittals, guilty D randomize between acceptance and rejection, and innocent D reject. This particularly applies to the peculiar case of $c_j/(2H - c_j) < \gamma < c_p/H$.

Thus, the judge can almost with certainty believe in the guilt of the defendant at J_2 and thus decides for the conviction. In the other SE, the judge would investigate the case at J_2, *(inv)*, and innocent defendants reject plea offers *(acc, rej)*. In this scenario outside the equilibrium path, the judge would prefer investigations at J_2 as possible 'trembles' cancel each other out, i.e. a guilty defendant rejects the plea bargain or the prosecutor charges an innocent defendant. Note that all this reasoning applies to off-equilibrium path events, so that the observable outcome of both SE is identical. Also, the *'reasonable doubt'*-decision standard holds as either belief $\mu_2 > \frac{\alpha}{1+\alpha}$ or strategy *(inv)* applies for the judge at J_2. We will explain in the discussion chapter that these SE are particularly remarkable and imply an increase in efficiency through plea bargaining.

Proposition 2.1 *The strategies* $\{(inv); (\Sigma, co); (acc, acc)\}$ *constitute a SE if* $\gamma < 1 - \frac{c_P}{\alpha H}$, $\gamma > \frac{c_P}{H}$ *and beliefs* $\mu_1 = 1$ *and* $\mu_2 = 1$ *apply.*

Proposition 2.2. *The strategies* $\{(inv); (\Sigma, inv); (acc, rej)\}$ *constitute a SE if* $\gamma < 1 - \frac{c_P}{T+L}$, $\frac{c_P}{H} < \gamma < \frac{\alpha H - c_J}{\alpha H + c_J}$, $\gamma > \frac{c_j}{2H - c_j}$ *and beliefs* $\mu_1 = 1$ *and* $\mu_2 = \frac{\gamma}{(1/2)+(1/2)\gamma}$ *apply.*

Proof See Appendix 3.

Note that an equilibrium where the judge always investigates the case and the prosecutor charges blindly cannot exist here: innocent defendants would never accept plea deals ($T < \Sigma \leq F$) if they can expect the judge to examine the case. If the innocent defendants rejected the deal and such cases reach court in equilibrium, the judge would prefer to acquit the defendant. This would make the guilty defendant reject the deal as well, and then again require investigations by the judge. Plainly, a SE in pure strategies where only the judge investigates the case cannot exist.

For high values of the probability of a guilty defendant γ, one SE in pure strategies exists where cases are never investigated, the prosecutor always charges, the judge always convicts, and all defendants accept the plea bargain. This equilibrium is obtained when the rational prosecutor prefers a 'blind' charge to further investigations and the probability of guilt exceeds the conviction threshold. This combination of strategies is only credible, however, when the high probability of guilt would convince the judge to convict any defendant without examining the evidence, otherwise the innocent defendant would never have accepted the plea bargain in the first place.

Proposition 3 *The strategies* $\{(ch); (\Sigma, co); (acc, acc)\}$ *constitute a SE if* $\gamma > 1 - \frac{c_P}{\alpha H}$ *and* $\gamma > \frac{\alpha}{1+\alpha}$ *hold, and beliefs* $\mu_1 = \gamma$ *and* $\mu_2 = \gamma$ *apply.*

Proof See Appendix 4.

4.2 Mixed strategies

Concerning potential mixed strategy equilibria, the following observations stand out: First, a scenario where the prosecutor randomizes between dropping the case and any other of her pure strategies is neglectable. Judge and defendants can always infer with certainty that the case was not dropped whenever their information set is reached, i.e. the game continues to stage 2 (see Fig. 1). Second, the judge cannot randomize between investigations and a 'blind' conviction. In this case, all guilty defendants would prefer the plea deal and there is no reason for the judge to convict the remaining innocent defendants.

In the following, we only focus on outcomes where the game does not end at stage 1. There exists a semi-separating equilibrium where two of the three players randomize: some guilty defendants accept the plea deal while the remaining guilty and all innocent defendants reject it, the judge investigates the case with positive probability and acquits otherwise, and the prosecutor always charges 'blindly'.

Proposition 4 *P chooses* (ch)*, J plays* (Σ,inv) *with probability* $\phi_J^*=\frac{\Sigma-T}{F}$ *and* (Σ,ac) *otherwise, and D plays* (rej,rej) *with probability* $\phi_G^*=\frac{c_J(1-\gamma)}{(H-c_J)\gamma}$ *and* (acc,rej) *otherwise, and this applies for* $\gamma>\frac{c_J}{H}$, $\gamma>\frac{T+L}{H+T+L}$, $\gamma>1-\frac{c_P}{T+L}$, *and the upper boundary* $\phi_G<\frac{\gamma H-(1-\gamma)(T+L)}{\gamma(H+T+L-\phi_J(H+L))}=\overline{\phi_G}$. *For every deal* Σ*, this strategy combination then constitutes a SE with judicial beliefs* $\mu_1(g|ch)=\gamma$ *and* $\mu_2=\frac{c_J}{H}$.

Proof See Appendix 5.

This mixed-strategy equilibrium shows some interesting properties. First, only the judge is able to make the (guilty) defendant indifferent between accepting or rejecting the plea bargain. For this, the judge randomizes between the strategies (Σ, inv) and (Σ, ac). Mixing between (Σ, inv) and (Σ, ac) then implies that no innocent defendant will be sentenced in equilibrium, but some guilty defendants may get away with the crime. Second, a weaker equilibrium deal offer Σ is supported by a lower probability of judicial investigations to maintain the indifference of the (guilty) defendant, as follows from the probability $\phi_J^* = \frac{\Sigma-T}{F}$. A maximizing judge who seeks to avoid effort and does not care about the effective punishment may thus be tempted to lower the plea offer Σ: a low plea offer is consistent with a low probability of effort ϕ_J^* and has no effect on the deal rejection rate by the guilty defendants ($\frac{\partial\phi_G^*}{\partial\Sigma} = 0$). As a caveat to this strategy, lowering the probability of judicial investigations negatively affects the upper boundary $\overline{\phi_G}$, i.e. it becomes more binding. Consequently, too little judicial effort and thus too many 'blind' acquittals may incentive the prosecutor to drop cases altogether. Clearly, this cannot be desirable for the judge (as $\gamma > \frac{c_J}{H}$ holds).

5 Discussion

5.1 Plea bargaining eliminates the freeriding dilemma

In contrast to adversarial criminal procedure where the judge has a rather passive role, the inquisitorial regime relies on two investigators, judge and prosecutor. Christmann and Kirstein (2022) demonstrated that this setting gives rise to a coordination problem: although both agents are motivated to convict only the guilty defendants, each player prefers that the other one bears the effort of investigations. This dilemma resembles the well-known battle-of-the-sexes game where two equilibria coexist, and each agent is the investigator in one of them and the other one freerides. Assuming that the prosecutorial office has a cost advantage over the judge due to its better resources and closer contact to the police force, efficiency would require the prosecutor to be the investigator.

Our analysis shows that allowing for plea bargaining between judge and defendant in the inquisitorial setting eliminates this freeriding dilemma in pure strategies. Simply put, the rational prosecutor can no longer take all cases to court and hope that the judge does all the work. Given plea bargaining, an outcome where the prosecutor charges blindly and the judge always investigates the case is no longer sequentially rational: if the judge examines the evidence, only the guilty defendants would accept the deal while all the innocent move to trial. If only the innocent proceed to trial, however, no investigation is needed. This dilemma makes the threat of investigations by the judge no longer credible.[21] It is due to this credibility problem that sequential rationality here requires the prosecutor to run the investigation (see *Proposition 2*). In other words, the introduction of plea bargaining solves the above discussed coordination problem between the two agents. Under the assumption of lower prosecutorial costs, this shift of effort to the prosecutor is also increasing efficiency. This remarkable result is further strengthened by the resistance of this outcome to small decision errors of the players.

Proposition 2.3 *For a given plea deal* Σ*, the strategies* $\{(inv);(co);(acc,acc)\}$ *and beliefs* $\mu_1 = 1$ *and* $\mu_2 = 1$ *constitute a (trembling-hand) perfect equilibrium of the uniformly perturbed game if* $\gamma < 1 - \frac{c_P}{\alpha H}$ *and* $\gamma \gg \frac{c_P}{H}$ *hold.*

Proof See Appendix 6.

Applying the more restrictive concept of Selten´s perfectness (see Kreps & Wilson, 1982), we reconsider Proposition 2.1 and find that the equilibrium strategies will also be chosen if each player considers small probability decision errors (‘*trembles*’) of the others during the game and if updated beliefs reflect such unintended errors. The only (minor) restriction is that the ex-ante probability of a guilty defendant must be more than just marginally above the lower threshold for the prosecutor, $\gamma \gg \frac{c_P}{H}$, so that the prosecutor is not very close to being indifferent between investigations or just dropping the case. Applying a numerical example of

[21] This clearly resembles the major finding of Baker and Mezzetti (2001) for an adversarial setting.

such 'trembles', we further illustrate that the occurrence of court errors is particularly sensitive to mistakes by the prosecutor.[22]

5.2 Less wrongful convictions

The coordination problem of judge and prosecutor in traditional inquisitorial procedures (see Christmann & Kirstein, 2022) produces a positive probability of wrongful convictions (type I errors) when both players randomize between investigations or 'blind' proceedings. It is remarkable that such wrongful convictions are fully avoided in the mixed strategy equilibrium once plea bargaining is introduced. All innocent defendants reject the deal, and even in court they are never convicted.

Without plea bargaining, the prosecutor randomizes between investigations and blind charges to make the judge indifferent, which strictly increases the posterior belief of the judge about the probability of facing a guilty defendant in court. In the end, the judge becomes indifferent between investigating the case or convicting the defendant right away, and the latter strategy produces some wrongful convictions. This is different when plea bargaining is introduced. In this mixed strategy equilibrium, the prosecutor brings all cases to court. Some guilty defendants may accept the deal and this decreases the posterior belief of the judge. Moreover, the judge cannot randomize between a blind conviction and investigations, as the guilty defendant would expect to get sentenced either way, and strictly prefers the plea deal. Consequently, the equilibrium posterior belief about the defendant´s guilt is thus lower, and the judge is eventually turned indifferent between investigations and a blind acquittal. From this it follows that under the standard assumptions in the literature, such as risk-neutrality and equal beliefs about court outcome (see Kobayashi & Lott, 1996; Shavell, 1982), the innocent defendant will not be convicted either way. As the guilty defendants are sentenced only after judicial investigations, this again satisfies the '*reasonable doubt'*-decision standard.

One may argue that the result of zero type I errors is driven by the assumption that investigations verify the defendant´s true type with certainty. However, type I errors did occur under this strong assumption in the setup without plea bargaining (see Christmann & Kirstein, 2022), so our analysis still reveals a systematic change in the production of wrongful convictions once plea bargaining is introduced. If adversarial legal system can indeed be described by a stronger aversion to type I errors (see Adelstein & Miceli, 2001), then the deduced reduction of wrongful convictions once plea bargaining is introduced to inquisitorial courts substantiates this presumption.

[22] Note that the SE of Propositions 2.1 and 2.2 are identical with regard to the outcome of the game. Thus, we consider Proposition 2.1 to demonstrate the robustness of this outcome. See Appendix 7 for the numerical example.

6 Extensions of the basic model

In the following, we will extend our basic model to address some challenges to inquisitorial plea bargaining and study whether the established equilibria are affected. For brevity, we explain modifications and findings, but leave the derivations to the appendix.

6.1 Moral hazard by the defendant´s attorney

While we assume in the basic model that the defendant himself will fully consider the implications of a plea offer, one could argue that in many criminal proceedings the defendant´s attorney is effectively the more relevant player and can strongly influence the defendant. This gives rise to moral hazard, as the preferences of the attorney may often not be aligned to the defendant´s interests (see, e.g., Garoupa & Stephen, 2008, p. 340–348). Critics could argue that particularly court-assigned defense attorneys are mainly driven to end proceedings quickly.

To discuss this concern, we make the following modifications: instead of D, let this be a three-player game between judge, prosecutor, and the defendant´s attorney (A). The defendant´s attorney is only considering expected effort in trial T and a reputation damage of F when losing the case in court. Further assume that $\Sigma = 0$ applies, which means that the attorney always prefers to get rid of the court-assigned case by a plea deal.[23] While this may be exaggerated, the modification exposes a relevant concern about attorney moral hazard in the plea bargain debate: A will agree to a plea deal even if the defendant is innocent and has the right to prove this in court. It is interesting to see that all pure strategy outcomes of our game still hold under such moral hazard by the defense attorney. The intuition behind this is that in this prosecution game, the innocent defendant´s attorney almost never receives a plea offer by the judge, as either cases are dropped by the prosecutor or only the guilty defendants are charged. Only if the ex-ante probability of guilt is very high, then all defendants´ attorneys receive a plea offer, as already in the basic game. Furthermore, the mixed strategy outcome would vanish in this scenario, given that A can never be made indifferent between going to trial or accepting a deal.

We find that a scenario of defense attorney moral hazard by itself does not change the outcome of the game when the (benevolent) preferences of the other two players are still intact.

6.2 Non-benevolent prosecutor

In the inquisitorial tradition, and in our basic model, the prosecutor is regarded as an impartial aide to the judge. One may question whether the prosecutor is really incentivized to reduce decision errors on behalf of society, or whether prosecutors are not more inclined to maximize convictions and guilty pleas.

To elaborate, suppose that the prosecutor does not care about court errors at all. Instead, she receives a private gain V, with $V > 0$, when reaching a conviction in

[23] We display the amended payoffs for the third player A in Appendix 8.

court or a guilty plea by the defendant. As a consequence, the prosecutor will prefer to negotiate plea deals to court proceedings, and convictions to the examination of evidence.[24] A prosecutor who maximizes convictions will then prefer to charge all defendants, despite some of them being innocent, whenever the defendants are expected to accept guilty pleas and the judge is expected to render a conviction. While this does have some impact on the equilibria of the game, its overall properties still do not change.[25] In particular, we note Corollary 1:

Corollary 1 *The strategies* $\{(inv);(\Sigma,co);(acc,acc)\}$ *are no longer a SE, but strategies* $\{(inv);(\Sigma,inv);(acc,rej)\}$ *still constitute a SE when P is non-benevolent.*

Low probability cases are dropped, as there are no gains for the prosecutor to seek charges when an acquittal is likely. High probability cases will make defendants plead guilty, and the prosecutor will thus always charge. For the intermediate, more uncertain cases, even the maximizing prosecutor will investigate the case when she expects the innocent defendants to reject all deal offers and the judge to examine the evidence in trial. In other words, only by investigating the case herself and thus selecting the guilty defendants for trial can the prosecutor avoid losing in court. This has an important implication: it is not the benevolence of the prosecutor that leads to some favorable results of the basic model, such as successful effort coordination and avoidance of wrongful convictions, but the credibility of the judge to eventually examine the case in trial.

6.3 Imperfect verification in trial and judicial oversight

Previous sections already highlighted the role of the judge as an institutional safeguard. But what happens when the judge is only imperfectly able to supervise the prosecutor and verify the evidence of the case is a possible concern for plea bargaining.

Consider a scenario where the judge has only imperfect verification skills in trial: let e_I (e_{II}) be the probability of error that the judge will find the defendant guilty (innocent) after judicial investigations while the defendant actually is innocent (guilty). As judicial investigations are associated with cost c_J, the judge´s decision to investigate will now depend "on the degree of accuracy [she] expect[s] ex-post, in adjudication" (see Kaplow, 1994, p. 316). For investigations to be worthwhile in our setup, we further require the inequalities $1-e_I>\gamma>e_{II}$ to hold. This ensures that investigations always improve the level of accuracy for the judge, compared to the

[24] See Appendix 9. The studied case of conviction-maximizing prosecutors seems to be more critical to plea bargaining than considering prosecutors not caring about trials ($T=L=0$).

[25] Propositions 1.2 and 2.1 do not hold in this scenario. For Proposition 2.2 and 3, thresholds are slightly modified. Proposition 1 is unaffected. See Appendix 9.

ex-ante probability of guilt.[26] Nevertheless, the added level of accuracy might be too little compared to the costs for the judge, and it is straightforward to deduce that the judge is less inclined to investigate cases compared to perfect verification skills.

We find that all the previously established pure strategy equilibria also hold under this modification. The intuition for this is that in most of the aforementioned equilibria, J does not even investigate the case on the equilibrium path. Only the equilibrium $\{(inv); (\Sigma, inv); (acc, rej)\}$ of Proposition 2.2 is affected in two ways: first, the range of values of the prior γ (or the judicial belief μ, respectively) for this equilibrium narrows as the judge is less inclined to choose imperfect investigations. Second, imperfect verification skills now impose some restrains on the equilibrium deal offer Σ. If guilty defendants hope to benefit from a positive probability of wrongful acquittals, a successful plea offer must be considerably lower than the punishment in court. Similarly, if innocent defendants fear a positive probability of wrongful convictions in court, a plea deal that seeks to separate the guilty from the innocent must not be too low. We note Corollary 2:

Corollary 2 *In this setup, the strategies* $\{(inv); (\Sigma, co); (acc, acc)\}$ *constitute a SE as in the basic model, while strategies* $\{(inv); (\Sigma, inv); (acc, rej)\}$ *form a SE with additional restrictions on the ex-ante probability* γ *and plea deal* Σ.

Generally, the impact of limited judicial verification skills on the outcome of the game is limited and all equilibria still apply. However, our findings support the idea that a limitation on sentence discounts in plea bargaining can be required when the probability of wrongful convictions is significant. Furthermore, we show that particularly the equilibrium where both agents investigate the evidence is weakened. Be reminded that, as studied in Sect. 5.2, it is exactly this sequential equilibrium that ensures investigations even by a non-benevolent prosecutor.

6.4 Timing of the plea bargain

Distinct from our basic (inquisitorial) model, the deal offer is usually made at the beginning of the game in models on adversarial plea bargaining (see, e.g., Baker & Mezzetti, 2001). Interestingly, our findings are sensitive to the timing of the deal:

To elaborate, consider the plea offer is made by the prosecutor (or judge) at the beginning of the game, so before node P_1.[27] As an immediate consequence, the favorable strategy combinations of *Proposition 2*, $\{(\text{inv}); (\Sigma, \text{co}); (\text{acc}, \text{acc})\}$ and $\{(\text{inv}); (\Sigma, \text{inv}); (\text{acc}, \text{rej})\}$, are no longer mutual best responses: in the former one,

[26] See Appendix 10 for a complete description of this model extension. We stylize court accuracy as a 'black box'-technology for the judge. An alternative way would be that the judge receives an informative evidence signal at the beginning of trial, e.g. Bjerk 2021, Christmann 2021, or that the judge can exert effort to increase the number of evidence signals, see Yilankaya, 2002.

[27] See amended game tree with upfront plea offers in the Appendix 11.

an innocent defendant would not accept the plea deal upfront if the prosecutor investigated the case in court and revealed his innocence. For the latter one, the prosecutor would prefer to drop charges if only innocent defendants are rejecting the deal. This leads us to:

Corollary 3 *If the plea bargain is instead made before decision node* P_1, *then strategy combinations* $\{(inv);(\Sigma,co);(acc,acc)\}$ *or* $\{(inv);(\Sigma,inv);(acc,rej)\}$ *are no longer a SE.*

We conclude that shifting the plea bargaining phase to the beginning of the inquisitorial setup shows a negative impact for intermediate values of the prior. More precisely, it rules out the one type of SE where investigations are certain and the evidence is always examined at lowest costs. What remains then is the well-known semiseparating equilibrium in mixed strategies (see Baker & Mezzetti, 2001). In other words, the timing of plea bargaining in courtroom and after initial investigations by the prosecutorial office avoids the commitment problem of adversarial plea bargaining, i.e. its mixed strategy equilibrium. Whether the approach to plea bargain in court, as in our setup, is reducing social costs compared to upfront bargains before prosecutorial investigations is mainly an empirical question: from our model, we hypothesize that plea bargains before the judge produce higher costs for prosecutors through investigative effort, but lower trial and error costs. Accordingly, we should expect that upfront bargaining saves resources from prosecutors but produces higher trial costs and generates more court errors.

7 Concluding remarks

Remark 1 The main point of this paper is that the introduction of plea bargaining eliminates the problem of effort coordination between the inquisitorial prosecutor and judge. With plea bargaining, the inquisitorial prosecutor can no longer hope to freeride on judicial investigations, and she always investigates the evidence of ambiguous cases before deals are made. This equilibrium is robust to small decision errors ('trembles') by the other players, and the outcome also holds under moral hazard by the defense attorney or a non-benevolent prosecutor who only seeks convictions and guilty pleas. However, if non-benevolence of the prosecutor coincides with limited verification skills of the judge, then the efficient outcome becomes more constrained.

Remark 2 The introduction of plea bargaining leads to a systematic reduction in wrongful convictions (type I errors). This becomes evident in the mixed strategy equilibrium where players randomize between their pure strategies: without plea bargaining, the stylized prosecution game yields no false acquittals but some wrongful convictions while the opposite applies once plea bargaining is introduced.

Remark 3 Limitations on sentence reductions are required only if the prosecutor is non-benevolent and judicial verification skills are imperfect. Each of these two constraints eliminates one of the two desirable pure strategy equilibria where the prosecutor investigates ambiguous cases: the former condition implies that the prosecutor will only examine evidence if she anticipates judicial oversight, which is exactly what the latter condition impedes. Under these caveats, the risk of court errors requires limitations on sentence reductions. More lenient plea deals may then be problematic when the probability of type I errors is a concern.

Remark 4 The correct timing of plea bargaining can also mitigate the commitment problem of the prosecutor: a deal offer made just before the trial starts is backed by the credible threat that, if a deal is rejected, the judge will eventually convict the guilty defendants. This supports the established practice in countries such as Italy or Germany. Whether total costs, i.e. costs due to investigations, trial procedures and court errors, are lower when deals are bargained directly before trial is a question for empirical research.

Appendix 1

Strategic form of the game

For each cell, the first row describes the payoff of the judge, the second row the defendant´s payoff and the third row the payoff of the prosecutor (Fig. 2). .

Fig. 2 Strategic form of the game

D plays (rej, rej)		Judge		
		investigate ***inv***	convict ***co***	acquit ***ac***
Prosecutor	Investigate ***inv***	$-\gamma T-\gamma c_J$ $-\gamma(F+T)$ $-\gamma T-c_p$	$-\gamma T$ $-\gamma(F+T)$ $-\gamma T-c_p$	$-\gamma(H+T)$ $-\gamma T$ $-\gamma(H+T+L)-c_p$
	charge ***ch***	$-T-c_J$ $-\gamma F-T$ $-T-(1-\gamma)L$	$-T-(1-\gamma)\alpha H$ $-F-T$ $-T-(1-\gamma)\alpha H$	$-T-\gamma H$ $-T$ $-T-\gamma H-L$
	drop ***dr***	$-\gamma H$ 0 $-\gamma H$	$-\gamma H$ 0 $-\gamma H$	$-\gamma H$ 0 $-\gamma H$

D plays (acc, acc)		Judge		
		investigate ***inv***	convict ***co***	acquit ***ac***
Prosecutor	Investigate ***inv***	0 $-\gamma\Sigma$ $-c_p$	0 $-\gamma\Sigma$ $-c_p$	0 $-\gamma\Sigma$ $-c_p$
	charge ***ch***	$-(1-\gamma)\alpha H$ $-\Sigma$ $-(1-\gamma)\alpha H$	$-(1-\gamma)\alpha H$ $-\Sigma$ $-(1-\gamma)\alpha H$	$-(1-\gamma)\alpha H$ $-\Sigma$ $-(1-\gamma)\alpha H$
	drop ***dr***	$-\gamma H$ 0 $-\gamma H$	$-\gamma H$ 0 $-\gamma H$	$-\gamma H$ 0 $-\gamma H$

D plays (acc, rej)		Judge		
		investigate ***inv***	convict ***co***	acquit ***ac***
Prosecutor	Investigate ***inv***	0 $-\gamma\Sigma$ $-c_p$	0 $-\gamma\Sigma$ $-c_p$	0 $-\gamma\Sigma$ $-c_p$
	charge ***ch***	$-(1-\gamma)(T+c_J)$ $-\gamma\Sigma-(1-\gamma)T$ $-(1-\gamma)(T+L)$	$-(1-\gamma)(T+\alpha H)$ $-\gamma\Sigma-(1-\gamma)(T+F)$ $-(1-\gamma)(T+\alpha H)$	$-(1-\gamma)T$ $-\gamma\Sigma-(1-\gamma)T$ $-(1-\gamma)(T+L)$
	drop ***dr***	$-\gamma H$ 0 $-\gamma H$	$-\gamma H$ 0 $-\gamma H$	$-\gamma H$ 0 $-\gamma H$

D plays (rej, acc)		Judge		
		investigate ***inv***	convict ***co***	acquit ***ac***
Prosecutor	Investigate ***inv***	$-\gamma(T+c_J)$ $-\gamma(F+T)$ $-c_p-\gamma T$	$-\gamma T$ $-\gamma(F+T)$ $-c_p-\gamma T$	$-\gamma(T+H)$ $-\gamma T$ $-c_p-\gamma(T+H+L)$
	charge ***ch***	$-\gamma(T+c_J)-(1-\gamma)\alpha H$ $-\gamma(F+T)-(1-\gamma)\Sigma$ $-\gamma T-(1-\gamma)\alpha H$	$-\gamma T-(1-\gamma)\alpha H$ $-\gamma(F+T)-(1-\gamma)\Sigma$ $-\gamma T-(1-\gamma)\alpha H$	$-\gamma(T+H)-(1-\gamma)\alpha H$ $-\gamma T-(1-\gamma)\Sigma$ $-\gamma(H+T+L)-(1-\gamma)\alpha H$
	drop ***dr***	$-\gamma H$ 0 $-\gamma H$	$-\gamma H$ 0 $-\gamma H$	$-\gamma H$ 0 $-\gamma H$

Fig. 2 continued

Appendix 2

Proof of Proposition 1

Proposition 1.1 *(i) If a deal is always rejected and the Judge acquits the defendant, the prosecutor's best response is to save effort and drop the case in the first place. If the prosecutor drops the case, all choices of the judge and the defendants are best responses, given that the case never reaches court. (ii) For (ac) being a best response of the judge in the subgame where P charges the defendant, given the beliefs* μ_2*, J must prefer acquittal to conviction which requires* $-(1-\mu_2)\alpha H - T > -\mu_2 H - T \Leftrightarrow \mu_2 < \frac{\alpha}{1+\alpha}$ *and J does not investigate the case* $-c_J - T < -\mu_2 H - T \Leftrightarrow \mu_2 < \frac{c_J}{H}$*. This belief is consistent in the tradition of* Kreps *and* Wilson *(1982): Given that the players 'tremble' in their strategies with a small probability* ε*, implying that at each information set, the equilibrium strategy by the player is actually played with probability* $1-\varepsilon$*. If there is one off-equilibrium strategy, it is played with probability* $\varepsilon/2$*. If there are two off-equilibrium strategies, each is played with probability* $\varepsilon/2$*. This yields the belief* $\mu_2(g|ch \cap rej) = \frac{\gamma\varepsilon(1-\varepsilon)}{\gamma\varepsilon(1-\varepsilon)+(1-\gamma)(\varepsilon/2)(1-\varepsilon)} = \frac{\gamma}{(1/2)+(1/2)\gamma}$*. The same rationale yields* $\mu_1(g|ch) = \frac{\gamma\varepsilon}{\gamma\varepsilon+(1-\gamma)(\varepsilon/2)} = \frac{\gamma}{(1/2)+(1/2)\gamma}$*. The belief is thus consistent with the strategies if* $\gamma < \frac{\alpha}{2+\alpha}$ *and*$\gamma < \frac{c_J}{2H-c_J}$*. Consequently, (rej, rej) is optimal for the defendants due to* $T<\Sigma$*.* □

Proposition 1.2 *(i) Given that all defendants will accept a plea deal, the prosecutor prefers dropping the case to investigations if* $-\gamma H > -c_p$*, which gives* $\gamma < \frac{c_p}{H}$*. In order to prefer (dr) to blind charges,* $-\gamma H > -(1-\gamma)\alpha H$ *has to hold, which implies* $\gamma < \frac{\alpha}{1+\alpha}$*. If the prosecutor drops the case, all choices of the judge and the defendants are best responses, given that the case never reaches court. (ii) The choice of (acc, acc) is sequentially rational for the defendant, as he will always prefer a plea deal to trial when his information set* D_1 *or* D_2 *is somehow reached, and the judge plays in equilibrium (co). For the judge to choose (co) when his information set* J_2 *is reached, his beliefs about the defendant's guilt must adhere to* $\mu_2 > \frac{\alpha}{1+\alpha}$ *and* $\mu_2 > 1 - \frac{c_j}{\alpha H}$*. This belief can be consistent: applying the concept of 'trembles' (see Proposition 1.1 for the specification), this yields the belief* $\mu_2(g|ch \cap rej) = \frac{\gamma\varepsilon^2}{\gamma\varepsilon^2+(1-\gamma)(\varepsilon^2/2)} = \frac{\gamma}{(1/2)+(1/2)\gamma}$*. The above established requirements for the judicial belief are met if also* $\gamma > \frac{\alpha}{2+\alpha}$ *and* $\gamma > \frac{\alpha H - c_j}{\alpha H + c_j}$ *holds. The same approach yields* $\mu_1(g|ch) = \frac{\gamma\varepsilon}{\gamma\varepsilon+(1-\gamma)(\varepsilon/2)} = \frac{\gamma}{(1/2)+(1/2)\gamma}$*.* □

Appendix 3

Proof of Proposition 2

Proposition 2.1 *For P to choose (inv), investigations are preferable to a blind charge,* $-(1-\gamma)\alpha H < -c_P \Leftrightarrow 1 - \frac{c_P}{\alpha H} > \gamma$*, and also to dropping the case,* $-c_p > -\gamma H \Leftrightarrow \gamma > \frac{c_p}{H}$*. Clearly, this justifies* $\mu_1 = 1$*. For the judge to choose (co)*

over the two alternatives, if his information set is reached, this requires a belief μ_2 *which satisfies* $\mu_2(g|ch \cap rej) > 1 - \frac{c_J}{\alpha H}$ *and* $\mu_2(g|ch \cap rej) > \frac{\alpha}{\alpha+1}$. *This belief is consistent: applying the concept of 'trembles' (see Proposition 1.1 for the specification), this yields the belief* $\mu_2(g|ch \cap rej) = \frac{\gamma(1-(\varepsilon/2))\varepsilon}{\gamma(1-(\varepsilon/2))\varepsilon+(1-\gamma)(\varepsilon^2/2)}$, *which is consistent in the limit* $\frac{\gamma(1-(\varepsilon/2))}{\gamma(1-(\varepsilon/2))\varepsilon+(1-\gamma)(\varepsilon/2)}, \underset{\varepsilon\to 0}{\to} 1$. *Note that the belief also meets the above established two requirements if* ε *is positive, but sufficiently small. Given (co), the defendants will always accept the deal at* D_1 *and* D_2. □

Proposition 2.2 *For P to choose (inv), investigations are preferable to a blind charge,* $-(1-\gamma)(T+L) < -c_P \Longleftrightarrow 1 - \frac{c_P}{T+L} > \gamma$, *and also to dropping the case,* $-c_p > -\gamma H \Leftrightarrow \gamma > \frac{c_p}{H}$. *Clearly, this justifies* $\mu_1 = 1$. *For the judge to choose (inv) over the two alternatives, if his information set* J_2 *is reached, this requires a belief* μ_2 *which satisfies the following requirements:* $\mu_2(g|ch \cap rej) < 1 - \frac{c_J}{\alpha H}$ *and* $\mu_2(g|ch \cap rej) > \frac{c_J}{H}$. *This belief is consistent: applying the concept of 'trembles' (see Proposition 1.1 for the specification), this yields the belief* $\mu_2(g|ch \cap rej) = \frac{\gamma(1-(\varepsilon/2))\varepsilon}{\gamma(1-(\varepsilon/2))\varepsilon+(1-\gamma)(\varepsilon/2)(1-\varepsilon)}$. *This gives in the limit* $\frac{\gamma(1-(\varepsilon/2))}{\gamma(1-(\varepsilon/2))+(1-\gamma)(1/2)(1-\varepsilon)} \underset{\varepsilon\to 0}{\to} \frac{\gamma}{(1/2)+(1/2)\gamma}$. *This belief meets the above established two requirements for* $\gamma < \frac{\alpha H - c_J}{\alpha H + c_J}$ *and* $\gamma > \frac{c_j}{2H - c_j}$. *Given J plays (inv), the guilty defendants accept and the innocent ones reject a plea deal.* □

Appendix 4

Proof of Proposition 3

For P to choose (ch) as best response to (co) and (acc, acc), (i) the blind charge must be preferable to investigations $-(1-\gamma)\alpha H > -c_P \Longleftrightarrow 1 - \frac{c_P}{\alpha H} < \gamma$ and (ii) the blind charge must be preferable to dropping the case altogether $-(1-\gamma)\alpha H > -\gamma H \Longleftrightarrow \frac{\alpha}{1+\alpha} < \gamma$. As cases are processed without prosecutorial investigations, belief $\mu_1 = \gamma$ is justified for the judge. Given (ch) and (acc, acc), J is indifferent between his three strategies, so strategy (co) is as good as his other options. Given (ch) and (co), D always prefers to accept the plea deal. For this Nash equilibrium to be sequentially rational, J must prefer a 'blind' conviction to (i) investigations and to (ii) an acquittal when his information set is reached, which requires (i) $\mu_2(g|ch \cap rej) > 1 - \frac{c_J}{\alpha H}$ and (ii) $\mu_2(g|ch \cap rej) > \frac{\alpha}{1+\alpha}$. Applying the concept of 'trembles' (see Proposition 1.1 for the specification), this yields the belief $\mu_2(g|ch \cap rej) = \frac{\gamma(1-(\varepsilon/2))\varepsilon}{\gamma(1-(\varepsilon/2))\varepsilon+(1-\gamma)(1-\varepsilon)\varepsilon}$. This gives in the limit $\frac{\gamma(1-(\varepsilon/2))}{\gamma(1-(\varepsilon/2))+(1-\gamma)(1-\varepsilon)} \underset{\varepsilon\to 0}{\to} \gamma$. This belief $\mu_2 = \gamma$ meets the above established two requirements, as we already established $\frac{\alpha}{1+\alpha} < \gamma$, and $\gamma > 1 - \frac{c_J}{\alpha H}$ always holds under $\gamma > 1 - \frac{c_P}{\alpha H}$. □

Appendix 5

Proof of Proposition 4

Consider the defendant. Only the judge is in a position to make the (guilty) defendant indifferent between accepting or rejecting the plea bargain. Given his three pure strategies $(\Sigma, inv), (\Sigma, co)$ and (Σ, ac), the mixing judge has two options. Randomizing between investigations and a 'blind' conviction can never make the guilty defendant indifferent as we assumed $\Sigma < F + T$. Guilty defendants then clearly prefer plea deals. Furthermore, only (some) innocent defendants would then move to court, which makes any conviction that occurs with positive probability unfavorable. Thus, the mixing judge must randomize between the strategies (Σ, inv) and (Σ, ac). Offering a deal Σ with $\Sigma = \phi_J F + T$ would then turn the guilty defendant indifferent between accepting or rejecting the deal, if the judge investigates the case with probability ϕ_J but otherwise acquits the defendant. Clearly, no innocent defendant would accept such a deal as he can expect to be acquitted either way. Solving for ϕ_J yields the mixing strategy for the judge with $\phi_J^* = \frac{\Sigma - T}{F}$, and $\phi_J^* \in (0; 1)$ for our assumption $T < \Sigma \leq F$.

Now consider the judge. As we established above, the judge can only be made indifferent between his strategies (Σ, inv) and(Σ, ac). This requires the judicial belief μ_2 about the defendant´s guilt in court to be $\mu_2 = \frac{c_J}{H}$. Assume ϕ_G describes the probability that the guilty defendant rejects the deal offer. Observing the charge and the rejection of the deal offer by the defendant, the judge updates his beliefs with $\mu_2 = \frac{\phi_G \gamma}{\phi_G \gamma + (1-\gamma)}$. Consequently, the judge is made indifferent by the other two players if $\frac{c_J}{H} = \frac{\phi_G \gamma}{\phi_G \gamma + (1-\gamma)}$ holds. Solved for the mixing strategy of the defendant, we find the mixed strategy $\phi_G^* = \frac{c_J(1-\gamma)}{\gamma(H-c_J)}$, and $\phi_G^* \in (0, 1)$ requires $\gamma > \frac{c_J}{H}$.

The prosecutor cannot be made indifferent between her pure strategies by the other two players: First, consider a scenario where the prosecutor should randomize between *(ch)* and *(inv)*. This would require $-c_P - \phi_G \gamma (T + (1 - \phi_J)(H + L)) = \phi_G \phi_J \quad (-T - (1-\gamma)L) + \phi_G(1 - \phi_J)(-T - \gamma H - L) + (1 - \phi_G)(-(1-\gamma)(T + L))$, but does not hold for $-c_P + (1-\gamma)(T + L) \neq 0$. It follows that P will always investigate if $\gamma < 1 - \frac{c_P}{T+L}$, which effectively precludes that J has any incentive to randomize. Thus, a potential mixed strategy equilibrium can only exist if P plays *(ch)*. This already requires $\gamma > 1 - \frac{c_P}{T+L}$. Furthermore, P needs to prefer her pure strategy *(ch)* to *(dr)* even when the other two players randomize. This gives $\phi_G \phi_J(-T - (1-\gamma)L) + \phi_G(1 - \phi_J) \quad (-T - \gamma H - L) + (1 - \phi_G)(-(1-\gamma)(T + L)) > -\gamma H$, which holds for $\phi_G < \frac{\gamma H - (1-\gamma)(T+L)}{\gamma(H+T+L-\phi_J(H+L))}$. The right-hand side is positive for $\gamma > \frac{T+L}{H+T+L}$. The mixed strategy of the guilty defendant ϕ_G^* satisfies this inequality for $\phi_G^* = \frac{c_J(1-\gamma)}{\gamma(H-c_J)} < \frac{\gamma H - (1-\gamma)(T+L)}{\gamma(H+T+L-\phi_J(H+L))} = \overline{\phi_G}$. As this inequality is relaxed for $\phi_J > 0$, we use $\phi_J = 0$ to illustrate that this condition holds for sufficiently high values of γ, and always if $\gamma > \frac{c_J+T+L}{H+T+L} > \frac{c_J}{H}$. □

Appendix 6

Proof of Proposition 2.3

A trembling-hand perfect (TH-perfect) equilibrium requires, in addition to the SE and its consistent beliefs, that each equilibrium strategy of the players must be robust to minor errors by the other players (see Kreps & Wilson, 1982, p. 864). We apply the normal form of the game as displayed in A1, take Σ as given and assume a uniformly perturbed game as follows: each player expects the other player´s to choose the equilibrium strategy with probability $(1-\varepsilon)$ and each of the remaining n non-equilibrium strategies with probability (ε/n). The uniform error probability ε is positive, but small.

(1) We illustrate this application with the judge who chooses the equilibrium strategy (co). Following the normal form, his expected payoff $\pi_J(co)$ is

$$\begin{aligned}\pi_J(co) =&(1-\varepsilon)\left[-\frac{\varepsilon}{3}\gamma T-\frac{\varepsilon}{3}\gamma T\right]\\&+\frac{\varepsilon}{2}\left[-(1-\varepsilon)(1-\gamma)\alpha H-\frac{\varepsilon}{3}(T+(1-\gamma)\alpha H)-\frac{\varepsilon}{3}(1-\gamma)(T+\alpha H)\right.\\&\left.-\frac{\varepsilon}{3}(\gamma T+(1-\gamma)\alpha H\right]+\frac{\varepsilon}{2}[-\gamma H],\end{aligned}$$

which can be simplified to$\pi_J(co) = -(1-\varepsilon)\frac{2}{3}\varepsilon\gamma T-\frac{\varepsilon}{2}\left[(1-\gamma)\alpha H+\frac{2}{3}\varepsilon T+\gamma H\right]$. We calculate the other payoffs accordingly. For (inv), he expects $\pi_J(inv) = -(1-\varepsilon)\frac{2}{3}\varepsilon\gamma(T+c_J)-\frac{\varepsilon}{2}\left[(1-\frac{2}{3}\varepsilon)(1-\gamma)\alpha H+\frac{2}{3}\varepsilon(T+c_J)+\gamma H\right]$. For (ac), he then expects $\pi_J(ac) = -(1-\varepsilon)\frac{2}{3}\varepsilon\gamma(H+T)-\frac{\varepsilon}{2}\left[(1-\frac{2}{3}\varepsilon)(1-\gamma)\alpha H+\right.$ $\left.\frac{2}{3}\varepsilon(T+\gamma H)+\gamma H\right]$. We find that $\pi_J(co) > \pi_J(inv)$ if $\varepsilon < \frac{2\gamma c_J}{(1-\gamma)\alpha H+c_J(2\gamma-1)} > 0$. The denominator is also positive, as either $\frac{\alpha H-c_J}{\alpha H-2c_J} > 1 > \gamma$ for $\alpha H-2c_J > 0$ or $\frac{\alpha H-c_J}{\alpha H-2c_J} < 0 < \gamma$ for $\alpha H-2c_J < 0$ always holds. We find that $\pi_J(co) > \pi_J(ac)$ if $\varepsilon < \frac{2\gamma H}{(1-\gamma)\alpha H+\gamma H} > 0$. Thus, (n, co) is robust to a small, but positive probability of error, and hence a *TH-perfect strategy* for the judge.

(2) The prosecutor chooses (inv) and expects the payoff $\pi_P(inv)$ with

$\pi_P(inv) = -c_P-\frac{2}{3}\varepsilon\gamma T-\frac{\varepsilon^2}{3}\gamma(H+L)$. If she chooses (ch), she expects.

$\pi_P(ch) = -\left(1-\frac{2}{3}\varepsilon^2\right)(1-\gamma)\alpha H-\frac{2}{3}\varepsilon T-\frac{\varepsilon^2}{3}(\gamma H+(2-\gamma)L)$. For (dr), she expects $\pi_P(dr) = -\gamma H$. We find $\pi_P(inv) > \pi_P(dr)$ for $\gamma > \frac{c_P}{H\left(1-\frac{\varepsilon^2}{3}\right)-\frac{2}{3}\varepsilon T-\frac{\varepsilon^2}{3}L}$. Note that for the denominator $H\left(1-\frac{\varepsilon^2}{3}\right)-\frac{2}{3}\varepsilon T-\frac{\varepsilon^2}{3}L < H$ applies for $\varepsilon > 0$, which shows $\frac{c_P}{H\left(1-\frac{\varepsilon^2}{3}\right)-\frac{2}{3}\varepsilon T-\frac{\varepsilon^2}{3}L} > \frac{c_P}{H}$. We thus conclude that $\gamma \gg \frac{c_P}{H}$ must apply for $\pi_P(inv) > \pi_P(dr)$ to be robust to 'trembles', i.e. the ex-ante probability of guilt must not be close to the threshold. A numerical example (H=10, T=2; L=5, c_p=3) illustrates that for ε=0.1

the threshold of $\frac{c_P}{H} = 0.3$ slightly increases to $\gamma > 0.306$ for $\pi_P(inv) > \pi_P(dr)$ to hold, and to $\gamma > 0.308$ for ε=0.2. Moreover, we find for $\pi_P(inv) > \pi_P(ch)$ the condition $\gamma < \frac{\alpha H - c_P + \frac{2}{3}\varepsilon(-\varepsilon\alpha H + T + \varepsilon L)}{\alpha H + \frac{2}{3}\varepsilon(-\varepsilon\alpha H + T + \varepsilon L)}$. For small $\varepsilon < \frac{T}{\alpha H - L}$, the condition $\frac{\alpha H - c_P + \frac{2}{3}\varepsilon(-\varepsilon\alpha H + T + \varepsilon L)}{\alpha H + \frac{2}{3}\varepsilon(-\varepsilon\alpha H + T + \varepsilon L)} > 1 - \frac{c_P}{\alpha H} > \gamma$ always holds. We conclude that (inv) is a *TH-perfect strategy* for the prosecutor for $\gamma \gg \frac{c_P}{H}$.

(3) For the defendant, the strategy (acc,acc) yields a payoff of

$\pi_D(acc, acc) = -(1-\varepsilon)\gamma\Sigma - \frac{\varepsilon}{2}\Sigma$. For (rej,rej) the payoff gives $\pi_D(rej, rej) = -(1-\varepsilon)\left[\left(1-\frac{1}{2}\varepsilon\right)\gamma F + \gamma T\right] - \frac{\varepsilon}{2}\left[T + (1-\varepsilon)F + \frac{\varepsilon}{2}\gamma F\right]$. Choosing (acc,rej) gives.

$\pi_D(acc, rej) = -\left(1-\frac{\varepsilon}{2}\right)\gamma\Sigma - \frac{\varepsilon}{2}[(1-\gamma)T + (1-\varepsilon)(1-\gamma)F]$, and the strategy (rej,acc) yields.

$\pi_D(rej, acc) = -\left(1-\frac{\varepsilon}{2}\right)[\gamma T + \left(1-\frac{\varepsilon}{2}\right)\gamma F] - \frac{\varepsilon}{2}(1-\gamma)\Sigma$. We find that $\pi_D(acc, acc) > \pi_D(rej, rej)$ yields the condition $(1-\varepsilon)\left[\left(1-\frac{1}{2}\varepsilon\right)F + T - \Sigma\right] > \frac{\varepsilon}{2}\left[\frac{\varepsilon}{2}\Sigma - T - (1-\varepsilon)F - \frac{\varepsilon}{2}\gamma F\right]$. While the right-hand side of the inequality is always negative, given Σ≤F and small errors ε, the left-hand side is positive for ε<(2 T/F), and then $\pi_D(acc, acc) > \pi_D(rej, rej)$ clearly holds. Moreover, $\pi_D(acc, acc) > \pi_D(acc, rej)$ applies for $1 - \frac{\Sigma - T}{F} > \varepsilon$. Lastly, we find that $\pi_D(acc, acc) > \pi_D(rej, acc)$ as $\Sigma < T + \left(1-\frac{\varepsilon}{2}\right)F$ holds for ε<(2 T/F) even under F=Σ. Thus, (acc,acc) is also a *TH-perfect strategy*. Given that the judicial beliefs are consistent for small 'tembles' ε (see proof in Appendix 3, Proposition 2.1) and all equilibrium strategies are *TH-perfect*, this combination of robust strategies and beliefs is a *TH-perfect equilibrium*. □

Appendix 7

Numerical example of 'trembles'

In order to illustrate the impact of 'trembles', we choose the example of $\varepsilon = 0.1$ for the reduced game. Court errors due to off-equilibrium behavior amounted to a probability of about 0.050(1-γ) for wrongful convictions and to a probability of about 0.055γ for a wrongful acquittal. The following game tree (see Fig. 3) illustrates the impact of decision errors. For the case of a guilty defendant, a wrongful *(dr)* by the prosecutor accounts for most wrongful acquittals, while a mistaken *(ch)* is largely compensated along the equilibrium path. For the case of innocent defendant, a mistaken (ch) largely leads to wrongful convictions, particularly as the other players play their equilibrium strategies.

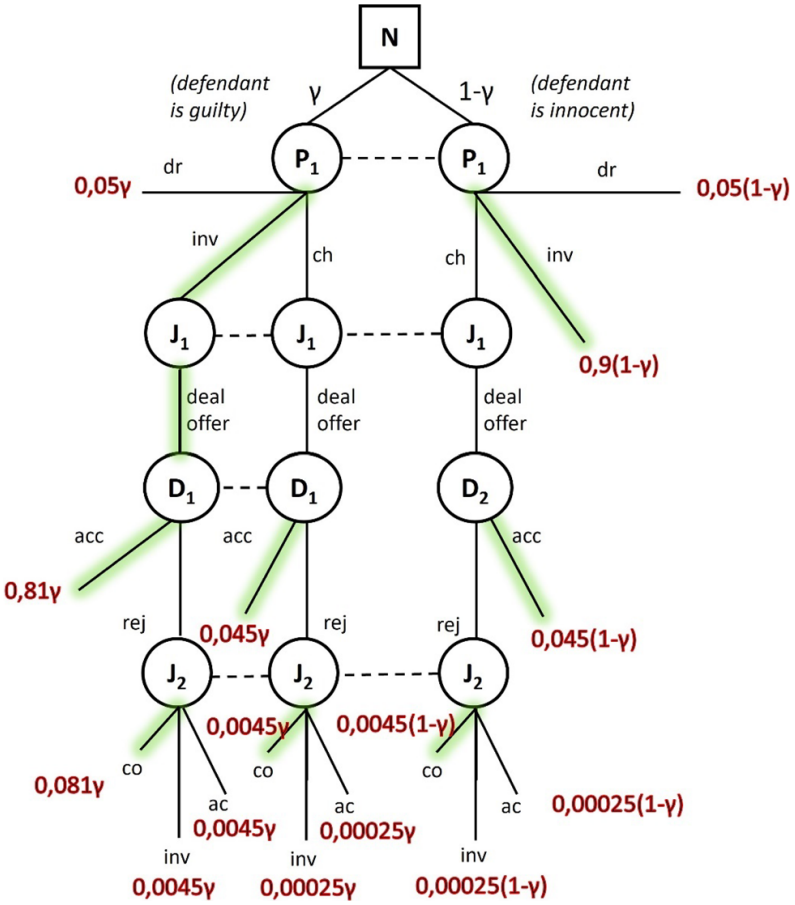

Fig. 3 Game tree, equilibrium path and trembles for ε=0.1

Appendix 8

Defense attorney moral hazard

For sake of brevity, only the amended payoffs of player A are displayed. Equilibria of the basic game are noted in brackets (Fig. 4).

Conjecture Chapter 6.1 All SE of the basic game are unaffected. *Proof*: Given that only D′s payoffs (now designated player A) are modified, for a SE to be affected it would require that the strategy combination is (i) no combination of best responses or ii) the equilibrium is no longer sequential rational. This does not apply here: i) As evident from the strategic form for Propositions 1, 2.1 and 3, A has no incentive to deviate from the former equilibrium strategy. (ii) Judicial beliefs are unaffected by the modification, thus the behavior of D and J outside the equilibrium path is unaffected.

A plays (rej, rej)		Judge		
		inv	*co*	*ac*
Prosecutor	*inv*	-γ(F+T)	-γ(F+T)	-γT
	ch	-γF-T	-F-T	-T
	dr	0	0	0 [Prop. 1.1]

A plays (acc, acc)		Judge		
		inv	*co*	*ac*
Prosecutor	*inv*	0	0 [Prop. 2.1]	0
	ch	0	0 [Prop. 3]	0
	dr	0	0 [Prop. 1.2]	0

A plays (acc, rej)		Judge		
		inv	*co*	*ac*
Prosecutor	*inv*	0 [Prop. 2.2]	0	0
	ch	-(1-γ)T	-(1-γ)(T+F)	-(1-γ)T
	dr	0	0	0

A plays (rej, acc)		Judge		
		inv	*co*	*ac*
Prosecutor	*inv*	-γ(F+T)	-γ(F+T)	-γT
	ch	-γ(F+T)	-γ(F+T)	-γT
	dr	0	0	0

Fig. 4 Strategic form of the game with attorney moral hazard

Appendix 9

Non-benevolent prosecutor

For sake of brevity, only the amended payoffs of P are displayed. Equilibria of the basic game are noted in brackets (Fig. 5).

In the following, we compare the basic game to this modification: Proposition 1.1 is unaffected by the changes to the payoffs of P. Proposition 1.2 does not hold, as P strictly prefers *(ch)* to *(dr)* when D and J play their equilibrium strategies. Proposition 3 holds with a slight change: as P always prefers *(ch)*, the lower threshold is now defined by the belief of the judge, which gives $\gamma > 1 - \frac{c_J}{\alpha H}$ (instead of $\gamma > 1 - \frac{c_P}{\alpha H}$ in the basic game). For Corollary 1, we find: Proposition 2.1 does not hold as the best response of P to the other players´ strategies is *(ch)*. Proposition 2.2 does hold with a slight change: for P to choose *(inv)* over *(dr)*, the condition $\gamma > \frac{c_P}{V}$ must hold (formerly, the condition was $\gamma > \frac{c_P}{H}$ in the basic model).

D plays (rej, rej)		Judge		
		inv	*co*	*ac*
Prosecutor	*inv*	$\gamma(V-T)-c_p$	$\gamma(V-T)-c_p$	$-\gamma(T+L)-c_p$
	ch	$\gamma V-T-(1-\gamma)L$	V-T	-T -L
	dr	0	0 [Prop. 1.1}	0

D plays (acc, acc)		Judge		
		inv	*co*	*ac*
Prosecutor	*inv*	$\gamma V-c_p$	$\gamma V-c_p$ [Prop. 2.1]	$\gamma V-c_p$
	ch	V	V [Prop. 3]	V
	dr	0	0 [Prop. 1.2]	0

D plays (acc, rej)		Judge		
		inv	*co*	*ac*
Prosecutor	*inv*	$\gamma V-c_p$ [Prop. 2.2]	$\gamma V -c_p$	$\gamma V -c_p$
	ch	$\gamma V -(1-\gamma)(T+L)$	$V-(1-\gamma)T$	$\gamma V -(1-\gamma)(T+L)$
	dr	0	0	0

D plays (rej, acc)		Judge		
		inv	*co*	*ac*
Prosecutor	*inv*	$\gamma(V-T)-c_p$	$\gamma(V-T)-c_p$	$-c_p-\gamma(T+L)$
	ch	$V-\gamma T$	$V-\gamma T$	$(1-\gamma)V-\gamma(T+L)$
	dr	0	0	0

Fig. 5 Strategic form of the game when P maximizes convictions

Appendix 10

Evidence production in trial and judicial oversight

For sake of brevity, only the amended payoffs of J are displayed. Equilibria of the basic game are noted in brackets (Fig. 6).

In the following, we compare the basic game to this modification:

First, it is easy to see that previous pure strategy equilibria are again Nash-equilibria: For J, all modifications do not incentivize J in any former SE to deviate from his previous equilibrium strategy, given the equilibrium strategies by the other two players. For P, however, there is a modification in his choice of (inv) under Proposition 2.2: P will prefer (inv) over (co) only if $-c_p > -(1-\gamma)(T+(1-e_I)L+e_I\alpha H)$, which then yields the threshold $\gamma<1-\frac{c_P}{T+(1-e_I)L+\alpha e_I H}$ (formerly: $\gamma<1-\frac{c_P}{T+L}$). Not surprisingly, this threshold is relaxed when errors occur with positive probability, as the prosecutor seeks to avoid court errors by investigating herself. For D, the only modification again applies under Proposition 2.2: he will prefer (acc) at node D_1 if $\Sigma<T+(1-e_{II})F$ and choose (rej) at node D_2 if $\Sigma > T+e_I F$. Evidently, the range for a separating plea deal under Proposition 2.2 narrows when error probabilities increase.

Second, sequential rationality must apply. For this we first determine what decision the judge will choose based on her beliefs: (i) For (inv) to be preferable to (co), the condition $-T-c_J-\mu e_{II}H-(1-\mu)e_I\alpha H > -T-(1-\mu)\alpha H$ must hold. This yields $\mu<1-\frac{c_J+e_{II}H}{(1-e_I)\alpha H+e_{II}H}$ (formerly: $\mu<1-\frac{c_J}{\alpha H}$), and this threshold decreases when error probabilities increase (if $c_J<(1-e_I)\alpha H$ is satisfied, otherwise always (co) is chosen). (ii) For (inv) to be preferable to (ac), the condition $-T-c_J-\mu e_{II}H-(1-\mu)e_I\alpha H > -T-\mu H$ must hold. This yields $\mu > \frac{c_J+e_I\alpha H}{(1+e_I\alpha-e_{II})H}$, and this threshold increases when error probabilities increase. Note that (i) and (ii) imply unambiguously that J will be less inclined to choose (inv) when judicial verification is imperfect. As Propositions 1.1, 1.2, 2.1 and 3 require J not to choose (inv) on the equilibrium path, and those Propositions held in the basic model, they also hold for this extension with positive error rates. For Proposition 2.2, as shown above considering (i) and (ii), however, the range $1-\frac{c_J+e_{II}H}{(1-e_I)\alpha H+e_{II}H} > \mu > \frac{c_J+e_I\alpha H}{(1+e_I\alpha-e_{II})H}$ for rational judicial beliefs μ becomes narrower when error rates increase. However, this belief can be sequentially rational as before if error rates are not too high (refer to Proposition 1.1 for the specification of 'trembles'). This proofs Corollary 2.

D plays (rej, rej)		Judge		
		inv	*co*	*ac*
Prosecutor	*inv*	$-\gamma(T+c_J+e_{II}H)$	$-\gamma T$	$-\gamma(H+T)$
	ch	$-T-c_J-\gamma\, e_{II}\, H$ $-(1-\gamma)\, e_I\, \alpha H$	$-T-(1-\gamma)\alpha H$	$-T-\gamma H$
	dr	$-\gamma H$	$-\gamma H$	$-\gamma H$ [Prop. 1.1]

D plays (acc, acc)		Judge		
		inv	*co*	*ac*
Prosecutor	*inv*	0	0 [Prop. 2.1]	0
	ch	$-(1-\gamma)\alpha H$	$-(1-\gamma)\alpha H$ [Prop. 3]	$-(1-\gamma)\alpha H$
	dr	$-\gamma H$	$-\gamma H$ [Prop. 1.2]	$-\gamma H$

D plays (acc, rej)		Judge		
		inv	*co*	*ac*
Prosecutor	*inv*	0 [Prop. 2.2]	0	0
	ch	$-(1-\gamma)\ (T+c_J+e_I\alpha H)$	$-(1-\gamma)(T+\alpha H)$	$-(1-\gamma)T$
	dr	$-\gamma H$	$-\gamma H$	$-\gamma H$

D plays (rej, acc)		Judge		
		inv	*co*	*ac*
Prosecutor	*inv*	$-\gamma(T+c_J+e_{II}H)$	$-\gamma T$	$-\gamma(T+H)$
	ch	$-\gamma(T+c_J+e_{II}H)$ $-(1-\gamma)\alpha H$	$-\gamma T-(1-\gamma)\alpha H$	$-\gamma(T+H)-(1-\gamma)\alpha H$
	dr	$-\gamma H$	$-\gamma H$	$-\gamma H$

Fig. 6 Strategic form of the game with imperfect judicial verification skills

Appendix 11

Plea bargaining at the beginning of the game

Conjecture Chapter 6.4 strategy combinations $\{(\text{inv}); (\Sigma, \text{co}); (\text{acc}, \text{acc})\}$ or $\{(\text{inv}); (\Sigma, \text{inv}); (\text{acc}, \text{rej})\}$ are no longer a SE. *Proof:* First, consider Proposition 2.1. This cannot be an equilibrium as the best response at information set D_2, given that P chooses (inv), is to reject the deal. Consider Proposition 2.2: This cannot be an equilibrium, as the best response to D, choosing (rej) at information set D_2 while choosing (acc) at D_1 is to drop the case. This concludes the proof (Fig. 7).

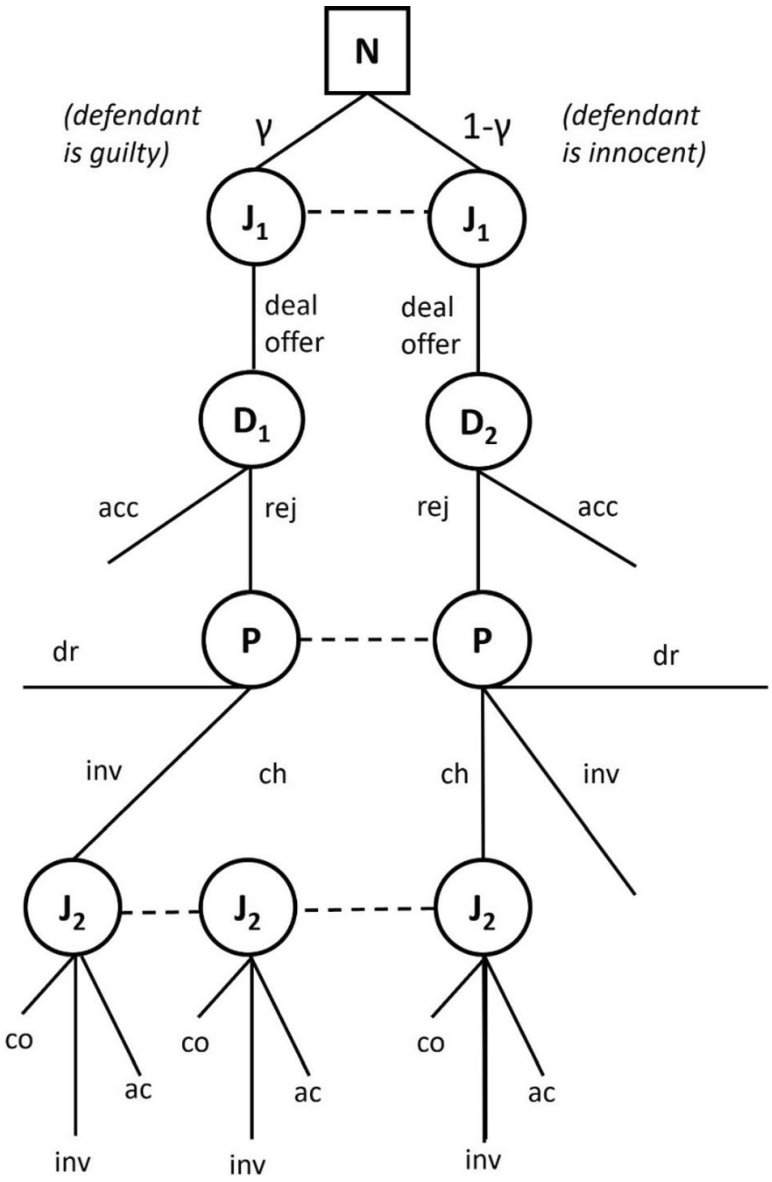

Fig. 7 Upfront timing of plea deals

Funding The authors did not receive support from any organization for the submitted work.

Declarations

Conflict of interest The authors have no relevant financial or non-financial interests to disclose

References

Adelstein, R. (1979). Informational paradox and the pricing of the crime. *Journal of Criminal Law and Criminology, 70*, 281–298.
Adelstein, R., & Miceli, T. (2001). Toward a comparative economics of plea bargaining. *European Journal of Law and Economics, 11*, 47–67.
Altenhain, K., Jahn, M., & Kinzig, J. (2020). *Die Praxis der Verständigung im Strafprozess*. Nomos: Baden-Baden.
Baker, S., & Mezzetti, C. (2001). Prosecutorial resources, plea bargaining, and the decision to go to trial. *Journal of Law, Economics & Organization, 17*, 149–167.
Bibas, S. (2004). Plea bargaining outside the shadow of trial. *Harvard Law Review, 117*, 2463–2547.
Bjerk, D. (2021). Socially optimal plea bargaining with costly trials and bayesian juries. *Economic Inquiry, 59*, 263–279.
Boari, N., & Fiorentini, G. (2001). An economic analysis of plea bargaining: The incentives of the parties in a mixed penal system. *International Review of Law and Economics, 21*, 213–231.
Burke, A. (2007). Prosecutorial passion, cognitive bias, and plea bargaining. *Marquette Law Review, 91*, 183–211.
Christmann, R. (2014). No judge, no job! court errors and the contingent labor contract. *European Journal of Law and Economics, 38*, 409–429.
Christmann, R. (2021). Prosecution and conviction under hindsight biased information updating in adversary legal systems. *Journal of Institutional and Theoretical Economics, 177*, 404–427.
Christmann, R., & Kirstein, R. (2022). You go first!: Coordination problems and the burden of proof in inquisitorial prosecution. *European Journal of Law and Economics*. https://doi.org/10.1007/s10657-022-09757-2
Covey, R. (2016). Plea bargaining and price theory. *George Washington Law Review, 84*, 920–971.
Easterbrook, F. H. (1992). Plea bargaining as compromise. *Yale Law Journal, 101*, 1969–1978.
Easterbrook, F. H. (2013). Plea bargaining is a shadow market. *Duquesne Law Review, 51*, 551.
Emons, W., & Fluet, C. (2009). Accuracy versus falsification costs: The optimal amount of evidence under different procedures. *Journal of Law, Economics, and Organization, 25*, 134–156.
Frankfurter Allgemeine Zeitung ('FAZ'). (2009). BGH-Präsident Tolksdorf kritisiert "Deals". https://www.faz.net/aktuell/politik/staat-und-recht/bgh-praesident-kritisiert-deals-in-strafprozessen-1757231.html. Downloaded 15.06.2021
Froeb, L., & Kobayashi, B. (2001). Evidence production in adversarial vs. inquisitorial regimes. *Economics Letters, 70*, 267–272.
Frommann, M. (2009). Regulating plea-bargaining in Germany: Can the italian approach serve as a model to guarantee the independence of german judges. *Hanse Law Review, 5*, 197–220.
Fudenberg, D., & Tirole, J. (1999). *Game Theory*. Cambridge: MIT Press.
Garoupa, N. (2009). Some reflections on the economics of prosecutors: Mandatory vs. selective prosecution. *International Review of Law and Economics, 29*, 25–28.
Garoupa, N. (2012). The economics of prosecutors. In A. Harel & K. Hylton (Eds.), *Research handbook on the economics of criminal law.* Northampton: Edward Elgar Publishing.
Garoupa, N., & Stephen, F. (2008). Why plea-bargaining fails to achieve results in so many criminal justice systems: A new framework for assessment. *Maastricht Journal of European and Comparative Law, 15*, 323–358.
Gazal-Ayal, O., & Tor, A. (2012). The innocence effect. *Duke Law Journal, 62*, 339–401.
Gennaioli, N. (2013). Optimal contracts with enforcement risk. *Journal of the European Economic Association, 11*, 59–82.

Givati, Y. (2011). The comparative law and economics of plea bargaining: theory and evidence. Discussion paper No. 39, Harvard Law School.
Grossmann, G., & Katz, M. (1983). Plea bargaining and social welfare. *American Economic Review, 73*, 749–757.
Hodgson, J. (2015). Plea bargaining: A comparative analysis. In J. D. Wright (Ed.), *International encyclopedia of the social & behavioral sciences* (pp. 226–231). Netherlands: Elsevier.
International Bar Association (IBA). (2021). Legality/opportunity principle regarding corporate criminal liability. https://www.ibanet.org/article/A835FD91-8EB7-4CBF-8AFE-E7E2E9562441 (downloaded 04.08.2023).
Jahn, M, & Hans, K. (2016). In: Harmut Schneider (ed.) *Münchener Kommentar zur Strafprozessordnung Band 2*. §257c, Rn. (pp. 57–58).
Kaplow, L. (1994). The value of accuracy in adjudication: An economic analysis. *Journal of Legal Studies, 23*, 307–401.
Kim, C. (2013). Adversarial and inquisitorial procedures with information acquisition. *Journal of Law, Economics & Organization, 30*, 767–803.
Kobayashi, B., & Lott, J. (1996). In defense of criminal defense expenditures and plea bargaining. *International Review of Law and Economics, 16*, 397–415.
Kreps, D., & Wilson, R. (1982). Sequential Equilibria. *Econometrica, 50*, 863–894.
Landau, H. (2011). Strafrecht nach Lissabon. *Neue Zeitschrift Für Strafrecht, 31*, 537–546.
Landes, W. (1971). An Economic Analysis of the Courts. *Journal of Law and Economics, 14*, 61–107.
Langbein, J. (1979). Land without plea bargaining: How the germans do it. *Michigan Law Review, 78*, 204–225.
Lewisch, Peter. (2000). Criminal procedure. In A. Marciano & G. Ramello (Eds.), *Encyclopedia of law and economics.* New York: Springer.
Miceli, T. (1990). Optimal prosecution of defendants whose guilt is uncertain. *Journal of Law, Economics, and Organization, 6*, 189–201.
Mungan, M., & Klick, J. (2016). Reducing false guilty pleas and wrongful convictions through exoneree compensation. *Journal of Law and Economics, 59*, 173–189.
Parlato, L. (2012). Ein Blick auf den italienischen Strafprozess: Vorbild oder abschreckendes Beispiel? Die aktuelle Situation und Gedanken zur Reform. *Zeitschrift Für Internationale Strafrechtsdogmatik, 10* (2012), 513–520.
Reinganum, J. (1988). Plea bargaining and prosecutorial discretion. *American Economic Review, 78*, 713–728.
Rönnau, T. (2018). Das deutsche Absprachemodell auf dem Prüfstand–Zwischen Pest und Cholera. *Zeitschrift Für Internationale Strafrechtsdogmatik, 5*, 167–177.
Schünemann, B. (2007). Die Zukunft des Strafverfahrens–Abschied vom Rechtsstaat? *Zeitschrift Für Die Gesamte Strafrechtswissenschaft, 119*, 945–958.
Shavell, S. (1982). Suit, settlement, and trial: A theoretical analysis under salternative methods for the allocation of legal costs. *Journal of Legal Studies, 11*, 55–81.
Spier, Kathryn. (2007). Litigation. In M. Polinsky & S. Shavell (Eds.), *Handbook of law and economics.* Heidelberg: North Holland.
Tirole, J., & Dewatripont, M. (1999). Advocates. *Journal of Political Economy, 107*, 1–39.
Tsur, Y. (2017). Bounding reasonable doubt: Implications for plea bargaining. *European Journal of Law and Economics, 44*, 197–216.
Tullock, G. (1994). Court errors. *European Journal of Law and Economics, 1*, 9–21.
UK Ministry of Justice. (2019). Criminal court statistics quarterly, England and Wales, January to March 2019. London.
Wohlers, W. (2010). Das Strafverfahren in den Zeiten der Eilkrankheit. *Neue Juristische Wochenschrift, 63*, 2470–2475.
Yilankaya, O. (2002). A model of evidence production and optimal standard of proof and penalty in criminal trials. *Canadian Journal of Economics, 35*, 385–409.