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Judicial Impact on Bankruptcy Efficiency: An Empirical Analysis of Case Duration in Serbian Bankruptcy Liquidations

Branko Radulović[1*]

[1] The University of Belgrade, Faculty of Law, Department of Economics, Belgrade, Serbia

ABSTRACT

This paper examines how judges shape the efficiency of liquidation proceedings, using case duration as a central indicator of procedural performance. Drawing on a dataset of over 1,300 closed bankruptcy liquidation cases in Serbia from 2010 to 2024, we apply hierarchical and cross-classified random-effects models to quantify the influence of judges, courts, and administrators, while controlling for case-level characteristics such as estate size, case complexity, contested claims, and debtor type. The analysis reveals substantial variation in case duration attributable to both judges and administrators, with administrators emerging as particularly influential in the cross-classified specifications. Moreover, we assess whether specific judge–administrator pairings systematically affect outcomes beyond their individual effects. While interaction effects are modest, they account for additional variation in procedural efficiency. The results highlight the importance of operational capacity and coordination between key institutional actors, offering evidence that agent-level discretion, beyond the legal framework, plays a role in shaping case trajectories. These findings contribute to the literature on judicial behavior, bankruptcy governance, and institutional performance in transitional legal systems.

Keywords: *bankruptcy proceedings, judges, administrators, hierarchical modeling, cross-classified models*

JEL Classification: G33, C21

INTRODUCTION

Bankruptcy laws and procedures play a critical role in enabling efficient resource reallocation and resolving financial distress (Blazy & Stef, 2020; Claessens & Klapper, 2005). The effectiveness of a bankruptcy framework is commonly assessed through three core metrics: recovery rates, costs, and the duration of proceedings (Djankov et al., 2008). Among these, the timely resolution of cases is often viewed as a key policy objective (Garrido et al., 2019), as delays typically reflect deeper systemic inefficiencies such as inflexible procedures, excessive caseloads, or limited institutional capacity (Stripp, 1992). Beyond being a procedural indicator, case duration also serves as a proxy for indirect costs that reduce the overall value recovered in bankruptcy (Bris et al., 2006; Franks & Torous, 1989; Thorburn, 2000).

The duration of bankruptcy proceedings is closely linked to the role of judges. A judge's ability to manage case complexity, schedule hearings efficiently, and make timely decisions can significantly affect both the cost and fairness of outcomes. Understanding the extent to which

* E-mail: bradulovic@ius.bg.ac.rs

judicial performance shapes bankruptcy efficiency is therefore critical for identifying institutional bottlenecks and informing reforms. This issue is particularly salient in Serbia, where, despite the adoption of a modern bankruptcy (Radović & Radulović, 2018), resolution times remain lengthy compared to peer countries such as Romania, Poland, and Hungary (Blazy & Stef, 2020). Understanding the factors driving these delays is essential to enhance the overall effectiveness of the insolvency framework and reduce the economic costs of prolonged proceedings.

Building on prior research by Radulović & Radović (2020), which highlighted unpredictability in judicial decision-making, largely due to inconsistently exercised discretionary powers, this study examines how judicial behavior influences the duration of bankruptcy cases in Serbia. Drawing on a unique dataset of bankruptcy liquidation cases concluded between 2010 and 2024, the study investigates the time from case initiation to final closure, employing multilevel modeling techniques to empirically assess the judicial and institutional determinants of procedural length. The analytical strategy combines two-level, three-level, and crossed random-effects models, enabling the decomposition of variation in case duration across judges, courts, and their interactions with bankruptcy administrators. This multilevel framework allows us to identify whether inefficiencies stem primarily from individual judges, broader court-level dynamics, or coordination with administrators.

This study makes several distinct contributions to the literature on judicial behaviour and bankruptcy efficiency. First, it introduces a hierarchical modeling framework to analyse judicial decision-making in bankruptcy. Second, by combining multilevel and crossed random-effects models, the study quantifies judicial heterogeneity and isolates systemic inefficiencies, enabling a more precise identification of whether delays stem from individual judges, court-level characteristics, or interactions with bankruptcy administrators. Third, by focusing on Serbia —an emerging economy where empirical research on insolvency systems is limited— the study provides much-needed evidence on the institutional determinants of procedural duration. These findings offer actionable insights for performance-based reform, contributing to more effective resource allocation and capacity-building within the commercial court system.

The remainder of the article is organized as follows. Section 2 reviews the literature on the role of judges in bankruptcy and the determinants of procedural duration. Section 3 outlines the institutional and legal framework governing Serbian bankruptcy proceedings. Section 4 presents the dataset and descriptive statistics. Section 5 details the empirical strategy and findings, comparing three model specifications: a two-level random-intercept model (cases nested within judges), a three-level model (judges nested within courts), and a crossed random-effects model (cases jointly influenced by judges and administrators). Section 6 concludes with a discussion of policy implications and directions for future research.

LITERATURE REVIEW

This article connects two overlapping lines of inquiry in the empirical bankruptcy literature. The first concerns the role and characteristics of bankruptcy judges, particularly how their decisions and discretionary powers shape procedural and substantive outcomes. While scholarly interest in the judicial role has grown, the empirical literature remains relatively limited and predominantly U.S.-focused. Much of the foundational research in this area examines judicial discretion in confirming reorganization plans, ruling on contested claims, and approving debtor applications.

More recent studies have examined judge-level heterogeneity in decision-making and its consequences for case outcomes. For instance, Chang & Schoar (2011) exploit the random assignment of bankruptcy cases in the U.S. to document significant variation in judicial behavior, linking this variation to differences in the efficiency of Chapter 11 proceedings. Similarly, Iverson et al. (2023), using a rotation-based methodology, show that judges with less bankruptcy experience are associated with significantly longer case durations, higher professional fees, and

lower creditor recoveries. These effects are most pronounced early in a judge's tenure and in more complex cases, underscoring the importance of specialization and learning-by-doing in judicial performance. These findings suggest that not only do judges matter, but the extent of their prior experience and exposure to bankruptcy law has measurable economic implications.

Beyond individual characteristics, scholars have also examined institutional factors. For example, Iverson (2017) links higher court congestion to longer case durations, a greater likelihood of liquidation, and lower post-bankruptcy survival rates. Leveraging quasi-random assignment of cases across courts, the study demonstrates that institutional constraints, independent of firm characteristics, significantly affect outcomes. Notably, the impact of congestion is greater for cases with more complex restructuring needs.

Other studies have explored the institutional and ideological dimensions of judicial behavior. (Nash & Pardo, 2012), emphasize that judges' normative commitments and interpretive philosophies can significantly influence how they approach reorganization, discharge, and fairness in bankruptcy. Their work highlights that judicial discretion is not only shaped by experience or capacity but also by underlying legal values, particularly in areas of statutory ambiguity. These insights are complemented by research on cognitive and behavioral biases. For example, Rachlinski et al. (2006, 2007) and Teichman & Zamir (2014) provide evidence that bankruptcy judges, like other decision-makers, are susceptible to subconscious heuristics and psychological framing effects, which can affect rulings in subtle but meaningful ways. Together, this body of work emphasizes that judges influence outcomes not only through formal rulings, but also through behavioral tendencies, interpretive discretion, and the institutional environments in which they operate.

In the U.S. context, scholars have shown that debtors exploit differences in judicial decision-making through forum shopping, strategically selecting jurisdictions perceived as more favorable to reorganization (Eisenberg & LoPucki, 1999; LoPucki & Doherty, 2004). More recently, He et al. (2020) demonstrated that judicial bias may vary systematically by court location.

Outside the U.S., however, empirical evidence remains sparse. Blazy et al. (2011) find that French judges tend to prioritize employee interests in insolvency cases, while Blazy & Esquerré (2021) show that the likelihood of reorganization varies systematically with the composition of the judicial chamber. Individual judge characteristics, such as managerial experience, academic background, and gender, significantly influence outcomes, indicating that procedural discretion persists even in systems designed to constrain it. They also identify a modest appointment bias, suggesting that case allocation is not fully random. In Russia, Lambert-Mogiliansky et al. (2007) document regional favoritism in court rulings.

In the Serbian context, Radulović & Radović (2020) identify significant unpredictability in judicial decision-making, which they attribute to inconsistently exercised discretionary powers. This unpredictability undermines legal certainty and contributes to procedural inefficiency. Together, these studies highlight the pivotal role that judges play in shaping both the pace and outcomes of bankruptcy proceedings, particularly in jurisdictions where judicial discretion is a defining feature of the legal framework.

The second strand of literature explores the determinants of bankruptcy efficiency, focusing on procedural duration, costs, and recovery rates. While many studies investigate the impact of case-related variables, such as creditor structure, presence of litigation, or asset complexity, on recovery outcomes, fewer treat duration itself as the dependent variable. Most commonly, time in bankruptcy appears as an independent variable used to explain variation in recoveries or costs (Bris et al., 2006; Ferris & Lawless, 1997, 2000). However, a more limited set of studies explicitly models the duration of proceedings as an outcome in its own right. Bris et al. (2006), for example, analyze a sample of 303 bankruptcy cases filed in the District of Arizona and the Southern District of New York, and show that procedural timelines are influenced by both case characteristics (such as proceeding type and creditor structure) and institutional variables, including judge and court

effects. Their findings show that judge fixed effects are highly significant, even after controlling for case-level variables.

While the U.S. literature is relatively well-developed, empirical studies from other jurisdictions remain comparatively scarce, though growing. Notable contributions include Bergström et al. (2004, 2005) on Finland, Thorburn (2000) on the Swedish auction model, Blazy & Nigam (2019) on England, Blazy & Stef (2020) on Central Europe, Cepec et al. (2017) on Slovenia, Couwenberg & de Jong (2008) on the Netherlands, Dewaelheyns & Van Hulle (2009) on Belgium, Aguiar-Díaz & Ruiz-Mallorquí (2015) on Spain, and Melcarne & Ramello (2020) on Italy. These studies collectively demonstrate that variation in institutional design, court efficiency, and legal culture can meaningfully affect case outcomes, particularly duration, costs, and creditor recoveries. Yet, evidence from transition economies—and especially from the Western Balkans—remains very limited. This article contributes to filling that gap by offering a systematic analysis of the determinants of case duration in Serbian bankruptcy liquidations, with a specific focus on judicial and institutional effects.

Overall, this literature suggests that case duration, often treated as a technical or administrative outcome, is, in fact, shaped by a complex interplay of case complexity, court capacity, and judicial behaviour. This study builds on that insight by applying multilevel modeling techniques to evaluate the influence of Serbian bankruptcy judges, courts, and administrators on the length of liquidation proceedings, contributing to the still-limited empirical research on insolvency systems in emerging markets.

Finally, hierarchical modelling as a methodological approach remains underutilized despite the inherently nested structure of court systems. Dalton & Singer (2014) use hierarchical linear modelling to examine how court structure influences the duration of civil cases. Drawing on a dataset of approximately 7,000 cases from seven U.S. district courts, they explore how the number of attorneys involved and the number of authorized judgeships per court affect case resolution times. Their findings reveal a counterintuitive interaction: while larger courts resolve simpler cases (those with three or fewer attorneys) more efficiently, smaller courts outperform larger ones in more complex cases involving multiple attorneys.

THE ROLE OF BANKRUPTCY JUDGES IN THE SERBIAN BANKRUPTCY FRAMEWORK

The Serbian Law on Bankruptcy, adopted in 2010, provides a framework for three primary procedures: bankruptcy liquidation, reorganization, and pre-arranged reorganization. While pre-arranged reorganization plans are predominantly utilized by large debtors (Radović & Radulović, 2018), the vast majority of insolvent small and micro-enterprises undergo liquidation, either through piecemeal asset sales or as a legal entity via going concern sales. The Law on Bankruptcy has undergone several subsequent amendments aimed at improving procedural efficiency, strengthening creditor protections, and streamlining the conduct of proceedings to reduce overall costs and duration.

Bankruptcy proceedings in Serbia commence upon the filing of a petition by either the debtor or a creditor. The bankruptcy judge first conducts a preliminary review to assess whether the statutory conditions for opening proceedings are satisfied. If the criteria are met, the court schedules a first hearing to formally initiate the process. At this initial creditors' hearing, the court examines available evidence and determines whether to officially open bankruptcy proceedings. If the motion is granted, the court appoints a bankruptcy administrator to manage the debtor's estate and oversee the liquidation process. This is followed by the examination hearing, during which creditors submit claims, and the financial position of the debtor is assessed. At this stage, the court verifies and confirms the list of creditors and their claims.

Following the examination hearing, the court issues a bankruptcy decision, determining whether the case will proceed to liquidation or reorganization. In liquidation proceedings, the process continues with the sale of the debtor's assets, which is conducted by the bankruptcy

administrator under the court's supervision. Assets may be sold through public auctions or direct sales, with the proceeds distributed to creditors in accordance with the statutory priority of claims. As the proceedings near completion, the administrator submits a final report detailing the asset distribution and settlement of claims. The court reviews this report to ensure compliance with all legal requirements before issuing a decision to close the bankruptcy case. After closure, the legality of the process is subject to final verification to confirm that both procedural and substantive obligations have been fully met.

Throughout the proceedings, the bankruptcy judge plays a key role in directing the course of the case. Core responsibilities include initiating preliminary bankruptcy proceedings, determining whether the legal grounds for opening bankruptcy exist, and supervising the appointment or dismissal of bankruptcy administrators. Judges must also approve costs incurred during the proceedings, including obligations charged to the bankruptcy estate, prior to their disbursement. Effective scheduling of hearings is essential, as judges are responsible for maintaining procedural timelines and ensuring that all parties, creditors, administrators, and other stakeholders receive proper notice and the opportunity to participate. Judges also adjudicate complaints regarding the conduct of bankruptcy administrators, thereby safeguarding accountability and compliance with applicable legal standards. In the final stages of the process, the judge oversees the distribution of the bankruptcy estate, ensuring that creditor claims are satisfied in accordance with the statutory order of priority.

Serbian bankruptcy judges share a relatively homogeneous professional background, as all are career judges with formal legal education and judicial experience. This professional uniformity mirrors practices in other jurisdictions, such as France (Blazy & Esquerré, 2021). However, variations in tenure and specialization in bankruptcy law may still significantly influence judicial decision-making and procedural outcomes. Unfortunately, data on these individual characteristics—such as years of service, prior case experience, or formal specialization—is not publicly available, thereby limiting empirical inquiry into their potential effects.

Judicial performance is also shaped by the institutional capacity and resource constraints of the courts in which judges operate. In smaller jurisdictions, the absence of specialized bankruptcy judges reflects a resource allocation strategy that emphasizes efficiency through an economy-of-scope approach. In Serbia, these judicial functions are carried out across 16 commercial courts, which differ markedly in terms of size, staffing, and caseload, typically in line with the economic significance of the regions they serve. Larger courts, such as those in Belgrade and Novi Sad, handle a disproportionately high volume of cases, often resulting in delays due to excessive caseloads and limited judicial resources. Conversely, smaller courts frequently struggle with insufficient specialization and staffing, impairing their capacity to effectively manage complex or contested bankruptcy proceedings.

In Serbia, bankruptcy cases are assigned to judges in accordance with the internal organizational rules of commercial courts, which include the use of an automated case assignment system. This system is intended to ensure an even distribution of workload among bankruptcy judges and to minimize the risk of subjective influence in the assignment process. The algorithm considers various factors, including the number of cases already assigned to each judge, the type of case, and, in some instances, case complexity and urgency. In smaller courts, particularly those lacking specialized bankruptcy judges, cases may also be assigned to generalist judges based on availability, which may result in variations in the experience and efficiency with which bankruptcy cases are handled across different courts.

While the automated system enhances transparency and reduces the likelihood of manipulation, potential concerns about endogeneity cannot be fully excluded. In practice, certain high-stakes or procedurally complex cases may be reassigned, typically by the President of the Commercial Court, to more experienced judges through internal administrative decisions. Such discretionary reallocation, though infrequent, may correlate with unobserved case characteristics that also affect duration, thereby introducing omitted variable bias and potentially distorting

estimates of judge-specific effects in empirical models. Recognizing these limitations is essential when interpreting the causal influence of judges on procedural outcomes.

DESCRIPTIVE STATISTICS AND VARIABLE CONSTRUCTION

Given that judges in Serbia primarily influence the pace rather than the outcome of proceedings, procedural duration offers a suitable metric for evaluating their impact. The duration of bankruptcy proceedings is typically measured from the commencement of the case to either the liquidation of the debtor's assets or the formal closure of the case. In Serbia, information on case duration can be drawn from both judicial statistics and reports submitted by insolvency administrators. This study relies on a uniquely detailed micro-level dataset compiled by the Bankruptcy Supervision Agency (BSA), the regulatory authority overseeing bankruptcy administrators. As part of its supervisory mandate, the BSA requires standardized reporting on all individual cases, resulting in a comprehensive and structured dataset that far exceeds the scope of typical judicial statistics in both depth and specificity. Comparable data is rarely available in other jurisdictions.

The dataset includes information on key procedural milestones, such as the timing of the first hearing, the examination hearing, the issuance of the bankruptcy decision, and the date of case closure and finality. While it does not contain precise dates related to individual asset liquidations, it offers a detailed breakdown of expenditures associated with estate administration. These include court and regulatory fees, administrator remuneration, expert consultation costs, storage and preservation expenses, auctioneer fees, and applicable government levies. The initial dataset comprises 5,774 closed bankruptcy liquidation cases. To ensure analytical robustness, several filters were applied. First, cases involving no assets or lacking essential data were excluded. Second, extremely short cases, defined as those lasting fewer than 30 days, were removed to avoid distortions caused by procedural anomalies or reporting errors. Third, to focus the analysis on economically meaningful proceedings, only cases with a minimum net inflow of approximately €8,000 were retained. This threshold ensures that the analysis concentrates on cases with substantive financial stakes, where judicial influence on procedural efficiency is more relevant. After applying these filters, the sample was reduced to 1,791 cases.

Finally, cases involving multiple presiding judges were excluded to enable proper attribution of case outcomes to individual judges. The presence of more than one judge over the course of a single proceeding makes it difficult to isolate the effect of any individual judge on case duration or procedural efficiency. Changes in judicial assignment can influence both the timeline and consistency of decision-making, thus complicating empirical attribution. Identification of cases with multiple presiding judges was conducted manually, as this information is not explicitly recorded in the database. In our dataset of 1,791 bankruptcy cases, we identified 443 cases (approximately 24.7%) involving a change in the presiding judge during the proceedings. In practice, changes in the presiding judge may occur for various reasons. These include retirement, reassignments to other departments, promotions (e.g., to the appellate commercial court), long-term illness, or temporary absences. Case reassignment may also be initiated administratively by the court president to balance caseloads or improve procedural efficiency. In exceptional circumstances, judges may be replaced due to substantiated complaints from parties or creditors regarding judicial conduct, or due to conflicts of interest, bias, or relationships that compromise impartiality. In rare cases, procedural errors identified on appeal may also lead to reassignment or recusal.

The dependent variable, *ln (duration in months)*, represents the natural logarithm of the time (in months) from the formal commencement of the bankruptcy procedure to the final closure of the case. This log transformation helps stabilize variance and mitigate the influence of extreme values. The transformed variable has a mean of 3.737 and a standard deviation of 0.771, with values ranging from 0.49 to 5.14, indicating substantial variability in procedural timelines (Table

1). In real terms, this corresponds to an average case duration of 55.2 months, with a standard deviation of 39.5 months. The shortest observed case lasted 1.6 months, while the longest extended to 170.5 months. This wide dispersion reflects underlying heterogeneity in case complexity, procedural efficiency, and the respective roles of judges and administrators.

Serbian bankruptcy judges face several structural and institutional constraints that can affect the duration of proceedings. A key limitation is the reliance on bankruptcy administrators, creditors, and external stakeholders, whose actions—or inactions—can delay the process. Even when judges adhere to prescribed timelines, the process may be prolonged due to late submissions, unverified claims, or protracted asset sales. Case complexity, particularly when involving valuation disputes, contested claims, or reorganization efforts, often extends deliberation periods beyond the judge's direct control. The reliance on external expert reports, especially for asset valuation, frequently creates procedural bottlenecks, as judges cannot move forward with critical rulings until those reports are submitted and reviewed. To account for variation in case size and complexity, several control variables are introduced.

Two continuous variables, *ln(net receipts)* and *ln(total claims)*, are used as proxies for the financial magnitude of bankruptcy cases. The mean of ln(net receipts) is 16.16 (SD = 1.55), corresponding to approximately 10.3 million RSD, or roughly €100,000.[1] In contrast, ln(total claims) has a higher mean of 18.23 (SD = 1.79), equivalent to about 91.2 million RSD, or approximately €887,000. The wide range in logged values—from 13.71 to 21.91 for net receipts and from 10.59 to 24.85 for total claims—translates into variation from about €8,700 to over €29 million in receipts, and from €390 to over €61 million in claims. These figures reflect substantial heterogeneity in case size and financial stakes.

The share of secured claims is included as an additional control variable, reflecting the capital structure of the bankrupt estate. On average, secured creditors account for approximately 19% of total claims, suggesting that in most proceedings, unsecured claims dominate the creditor structure. The standard deviation of 0.256 indicates considerable variation across cases in the distribution between secured and unsecured debt. This variation is relevant for understanding differences in procedural dynamics, as the presence of secured creditors is expected to influence both the complexity and the duration of the proceedings. A higher share of secured claims may be associated with shorter durations, since secured creditors typically have well-defined legal rights and collateral, which can expedite asset realization and reduce disputes. On the other hand, in some cases, the enforcement of security interests—especially when involving large or illiquid assets—may introduce delays. Thus, the net effect of secured claims on duration is theoretically ambiguous and must be determined empirically. Including this variable allows us to account for the degree to which differences in capital structure contribute to variation in procedural efficiency across cases.

In bankruptcies involving state-owned enterprises, the Bankruptcy Supervision Agency (BSA) itself serves as the administrator. These cases typically arise from the legacy of the transition period, where many insolvent enterprises with significant public ownership or unresolved legal obligations continue to appear in bankruptcy courts. In such proceedings, the BSA appoints a trustee from its pool of certified professionals, who operate under the agency's direct supervision. These BSA-appointed trustees are subject to additional reporting and compliance obligations, reflecting the agency's regulatory function as well as its administrative role. In the dataset, these cases are consistently categorized as involving a bankruptcy administrator, allowing for a uniform comparison with proceedings managed by private-sector administrators. Notably, approximately 9% of the cases in our sample involve the BSA. These proceedings often involve larger and more complex estates, substantial employee-related claims, or unresolved obligations toward public creditors such as tax authorities or state-owned utility providers. As such, they may exhibit

[1] All euro values are approximate, as the exchange rate between the dinar and the euro fluctuated during the observation period.

distinct patterns in terms of procedural duration, administrative costs, and judicial involvement. Additional proxies for case complexity include a binary variable indicating the presence of contested creditor claims. Approximately 56.8% of cases involve at least one disputed claim. This high percentage suggests that legal contestation is common and adds a considerable procedural burden, often extending the timeline of the case.

In the Serbian legal framework, the formal closure of bankruptcy proceedings does not necessarily mark the end of all case-related activities. A proceeding may be officially closed by the court while the bankruptcy estate remains active, meaning that certain post-closure tasks, such as asset liquidation, resolution of outstanding claims, or continuation of related litigation, still require administrative follow-up. To capture this distinction, a binary variable is included indicating whether the bankruptcy estate remained active after the formal closure of the case. In 33.8% of cases, the estate continued to exist beyond the official termination of proceedings, implying an extended administrative role for the bankruptcy trustee under ongoing court oversight. This institutional feature reflects a procedural separation between the legal closure of the case and the practical completion of estate-related obligations. A separate binary variable captures whether the bankruptcy procedure involved a going-concern sale, that is, the sale of the legal entity as an operational whole, rather than liquidation of individual assets. Going concern sales are likely to follow a different procedural trajectory, potentially influencing the duration of the case. In the dataset, 260 out of 1,337 cases, or approximately 19.4%, involved a going-concern sale. While still a minority of cases, this share suggests that the practice is not uncommon in Serbian bankruptcy proceedings and may reflect efforts to prioritize economic efficiency and value maximization where feasible.

Table 1. Descriptive Statistics

Variable	Obs.	Mean	Std. dev.	Min	Max
ln (duration in months)	1,337	3.723	0.770	1.110	5.14
ln (net receipts)	1,337	16.156	1.551	13.71	21.91
ln (total claims)	1,337	18.235	1.786	10.59	24.85
Secured creditors share	1,337	0.192	0.256	0	1
BSA as administrator	1,337	0.091	0.287	0	1
Bankruptcy estate	1,337	0.333	0.471	0	1
Contested creditors dummy	1,337	0.568	0.496	0	1
Going Concern Sale	1,337	0.194	0.396	0	1
Law					
2010	1,337	0.710	0.454	0	1
2014	1,337	0.162	0.368	0	1
2017	1,337	0.075	0.262	0	1
2018	1,337	0.054	0.225	0	1

Source: Author's calculation

To account for procedural variation introduced by changes in legislation, we include dummy variables for the applicable version of the Bankruptcy Law. Most cases (71.10%) fall under the 2010 version of the law, with smaller shares under the 2014 (16.2%), 2017 (7.5%), and 2018 (5.4%) amendments. This distribution reflects the legal evolution of the bankruptcy framework in Serbia and enables us to assess whether legislative reforms had any measurable effect on the duration of proceedings. However, it is important to note that a significant number of cases initiated under the 2017 and 2018 amendments were still ongoing at the time of data collection. As a result, these cohorts may be underrepresented in the sample of completed (closed) cases, potentially biasing observed duration estimates downward for more recent reforms. This should be kept in mind when interpreting the estimated effects of the 2017 and 2018 legal changes.

The dataset also reveals the geographic distribution of bankruptcy cases across Serbia's commercial courts, illustrating substantial regional variation. The Belgrade Commercial Court accounts for the largest share, handling approximately 20.5% of all cases in the data, followed by Novi Sad with 11.8%. Other mid-sized courts, such as Kragujevac, Niš, and Valjevo, manage moderate caseloads ranging from 6.7% to 8.6%. In contrast, smaller courts handle significantly fewer proceedings, with each contributing between 2.4% and 2.8% of the total. This distribution reflects the concentration of bankruptcy activity in economically significant regions, where business density and enterprise size are generally higher. Conversely, lower caseloads in smaller courts may be associated with lower levels of commercial activity.

The distribution of bankruptcy judges across courts also varies according to jurisdiction size. The data include a total of 141 judges who presided over at least one closed bankruptcy case. The Belgrade Commercial Court again stands out, with 41 judges represented in the data. In contrast, smaller courts typically have only two to six judges responsible for all commercial matters, including bankruptcy. During the period of elevated bankruptcy activity between 2010 and 2012—likely a residual effect of post-crisis financial distress, a broader group of judges was assigned to handle insolvency proceedings. However, as the number of new filings declined in subsequent years, the number of judges actively presiding over bankruptcy cases was reduced, reflecting changes in workload distribution and specialization at the court level.

A notable limitation of our data set is the lack of publicly available data on individual judges. Information such as years of judicial experience, number of previously handled bankruptcy cases, or formal specialization in bankruptcy law is not accessible. This absence of judge-specific variables limits the ability to control for unobserved heterogeneity in judicial behaviour and prevents the use of judge fixed effects in the estimation strategy. Consequently, differences in case duration that may be driven by variation in experience, decision-making style, or informal practices cannot be fully accounted for, which may lead to biased estimates or obscure important sources of procedural variation.

METHODOLOGY AND RESULTS

Hierarchical, or multilevel, models are designed to analyse data with a nested or clustered structure, allowing researchers to estimate the effect of variables at multiple levels of aggregation (Heck et al., 2020; Hox et al., 2017; Rabe-Hesketh & Skrondal, 2022; Snijders & Bosker, 2012). In this context, bankruptcy cases are nested within judges and courts, as cases handled by the same judge or within the same court may share common features due to similar decision-making styles, experience levels, or resource availability. Hierarchical modelling corrects for the non-independence of observations within these groups, thereby producing more accurate estimates of standard errors and variance components.

Random-effects models are particularly well-suited for this analysis, as they account for unobserved heterogeneity among judges, administrators, and courts by modelling their effects as drawn from underlying distributions. While the dataset includes nearly the full population of relevant agents, treating these institutional units as random effects enables estimation of group-level variance components and improves inference on case-level predictors through partial pooling. This approach is especially appropriate in settings with many groups, such as over 140 judges and 16 commercial courts, where fixed-effects models would require a prohibitive number of parameters and absorb much of the between-group variation. While fixed effects are useful for controlling for unobserved heterogeneity, their use here would limit our ability to assess and quantify how case outcomes vary across institutional actors.

Bankruptcy case duration is shaped by a combination of factors at multiple levels: case-level characteristics (e.g., debtor type, complexity, or contested claims), judge-level factors (e.g., experience, workload management), and court-level features (e.g., staffing, administrative support, or procedural infrastructure). Hierarchical models allow us to decompose the total

variance in case duration into components attributable to each of these levels. For example, some judges may consistently allow longer timelines, while well-resourced courts may resolve cases more efficiently. Random intercepts are used to model systematic differences between groups, such as consistently longer or shorter durations among certain judges, while random slopes would allow the effect of specific predictors to vary across groups. However, due to the lack of detailed judge-level covariates, we focus on random-intercept models, which still yield important insights into multilevel influences on procedural efficiency.

We begin by estimating a two-level random-intercept model to examine the extent to which variation in case duration can be attributed to individual judges. This baseline specification captures between-judge differences, such as variation in decision-making style or caseload management, while controlling for case-level characteristics. In the second stage, we extend the model to a three-level hierarchical structure by introducing court-level random effects, thereby accounting for the institutional environment in which judges operate. Finally, we estimate a crossed random-effects model to capture the independent and non-nested influence of both judges and bankruptcy administrators, acknowledging that these agents jointly affect case outcomes but are not hierarchically organized.

Two-Level Random-Intercept Model

We employ a two-level random-intercepts model to account for unobserved heterogeneity in case duration across judges, while accommodating limitations in the available data. Specifically, the dataset lacks judge-level (Level 2) covariates such as experience, specialization, workload, or appointment history, which precludes the inclusion of such variables in the model. In the absence of judge-level predictors, a random-intercept specification provides a practical and theoretically sound approach to modeling between-judge variation. This model allows each judge to have a unique baseline case duration, capturing systematic but unobserved differences in judicial behavior. It assumes that case-level predictor effects are constant across judges.

The dataset used for the two-level model treats bankruptcy cases as nested within judges and includes 1,337 cases presided over by a single judge. These cases are distributed across 141 unique judges, averaging approximately 9.5 cases per judge. This structure meets the general rule-of-thumb (minimum ~42 clusters) for relying on the asymptotic properties of standard errors in mixed-effects models (Rabe-Hesketh & Skrondal, 2022; Snijders & Bosker, 2012).

Let y_{ij} denote the outcome variable defined as the natural logarithm of case duration in months, for case i presided over by judge j. The baseline model is specified as:[2]

$$y_{ij} = \beta_0 + \beta_1 x_{1ij} + \cdots + \beta_p x_{pij} + \xi_{ij} \qquad (1)$$

Here x_{1ij} through x_{pij} represent case-specific covariates, and ξ_{ij} is a residual term. Assuming independent residuals across cases is likely unrealistic (Grotti & Cutuli, 2018), as multiple cases are handled by the same judge. To model this, we decompose the residual into

$$\xi_{ij} \equiv \zeta_j + \varepsilon_{ij} \qquad (2)$$

where ζ_j is a judge-specific component which remains constant across the cases, and ε_{ij} is a case-specific error term (varies between cases and across judges).

Substituting this decomposition into the model yields the two-level linear mixed model (Rabe-Hesketh & Skrondal, 2022):

[2] Note that different notations and formulations of multilevel models exist; this paper follows the notation and modelling framework of Rabe-Hesketh & Skrondal (2022).

$$y_{ij} = \beta_0 + \beta_1 x_{1ij} + \cdots + \beta_p x_{pij} + \zeta_j + \varepsilon_{ij} = (\beta_0 + \zeta_j) + \beta_1 x_{1ij} + \cdots + \beta_p x_{pij} + \varepsilon_{ij} \quad (3)$$

The random intercept ζ_j captures judge-specific deviations from the mean due to unobserved characteristics. A positive ζ_j implies that judge j tends to preside over longer cases, even after adjusting for case-level characteristics.

To assess the contribution of judge-level heterogeneity, we compute the intraclass correlation coefficient (ICC):

$$\rho(judge) = Corr(y_{ij}, y_{i'j'} | X_j) = \frac{\psi}{\psi + \theta} \quad (4)$$

where $\psi = Var(\zeta_j | X_j)$ is the between-judge variance, and $\theta = Var(\varepsilon_{ij} | X_j, \zeta_j)$ is within-judge (case-level) variance. A higher ICC indicates that a greater portion of case duration variability is explained by judges rather than individual case characteristics. An ICC$= 1$ all variation in case duration is due to differences between cases, not judges, while if $\rho = 0$ judges do not systematically differ in how long their cases take.

Following Rabe-Hesketh and Skrondal (2022), we adopt a modeling approach to investigate variation in case duration across judges. We begin with a between-effects model, which aggregates case-level data to the judge level and captures how variation in average predictor values explains variation in average case duration across judges. This isolates between-judge heterogeneity but omits variation within judges' caseloads. Next, we estimate a within-effects model (also known as a fixed-effects specification in the sense of group-mean centring). This model captures how the same judge handles different types of cases but discards between-judge differences. It estimates only within-judge variation by subtracting each judge's average from the case-level variables.

To leverage both levels of information, we estimate a random-intercepts linear mixed model using restricted maximum likelihood (REML). This model assumes that judges differ by a random intercept that captures unobserved heterogeneity, while allowing us to estimate both within- and between-cluster effects. A likelihood-ratio test confirms that judge-level random intercepts significantly improve model fit, rejecting the null hypothesis that between-judge variance equals zero. This provides strong evidence for the presence of meaningful judge-level heterogeneity in case duration. However, a significant Hausman test suggests that some case-level covariates are correlated with judge-specific effects, violating the random-effects assumption that these covariates are exogenous relative to the judge intercept. Specifically, predictors like claim value and legal regime may not be randomly distributed across judges — for example, some judges may systematically handle more complex cases or interpret reforms differently. This endogeneity introduces bias in standard random effects models and undermines the consistency of estimated coefficients.

To address this, we implement the Mundlak correction (Mundlak, 1978), which augments the random-effects model by including the judge-specific mean of each case-level predictor as an additional covariate. This adjustment controls for unobserved judge-level characteristics that correlate with those predictors. Intuitively, the Mundlak approach separates within-judge effects (how variation in case features affects duration for the same judge) from between-judge effects (how judges with systematically different case profiles differ in outcomes). The result is a model that retains the efficiency of random-effects estimation while relaxing its strict exogeneity assumptions, thereby producing consistent and interpretable estimates.

For each model, the table is divided into a fixed part and a random part, reflecting the structure of multilevel (mixed effects) estimation. The fixed part includes the estimated coefficients for the predictor variables — these represent the average effect of each covariate across all units (cases,

judges, courts). The random part reports the estimated variance components (and standard deviations) at each level of the data hierarchy: case-level residual variance, judge-level intercept variance. These variance components allow us to assess how much of the total variation in case duration is attributable to systematic differences across judges and courts, rather than variation across individual cases. In particular, the random intercepts capture unobserved heterogeneity at each level, and the intraclass correlation coefficients derived from them quantify the proportion of total variance due to clustering at higher levels.

The dataset used for the two-level model includes 1,348 bankruptcy cases, each presided over by a single judge. These cases span 142 judges, with an average of 9.5 cases per judge. As emphasized in the multilevel modeling literature models (Rabe-Hesketh & Skrondal, 2022; Snijders & Bosker, 2012), reliable estimation of between-group variance typically requires at least 42 groups, with stronger precision from 100 or more. With 142 judges, our data supports robust inference.

We now examine the main empirical results, with emphasis on the Mundlak-adjusted random-intercepts model (Model 4), which provides consistent estimates while accounting for judge-level heterogeneity. As the dependent variable is the natural log of case duration (in months), the model coefficients are interpreted as semi-elasticities when the independent variables are in levels (e.g., binary or non-transformed variables) — that is, as the approximate percentage change in duration for a one-unit change in the covariate. For predictors that are also log-transformed (e.g., ln(net receipts), ln(total claims)), the coefficients are interpreted as elasticities — the percentage change in duration resulting from a 1% increase in the predictor.

As expected, both measures of case size and complexity—the log of net receipts and the log of total claims—are positively and significantly associated with case duration. A 1% increase in net receipts is associated with an approximate 0.084% increase in case duration, holding other variables constant. Similarly, a 1% increase in total claims is associated with an additional 0.051% increase in case duration. Cases involving socially- or state-owned companies, captured by the BSA variable, are associated with a 0.226 unit increase in the log of duration, equivalent to an approximate 25.4% increase in case length. This robust and significant effect suggests that these cases are systematically more complex and time-consuming, likely due to bureaucratic constraints, unclear asset ownership, and unresolved liabilities.

Table 2. Two-level models

	(1) Within effects FE		**(2) Between effects BE**		**(3) Random effects REML 2L**		**(4) Random effects plus clustered mean REML MUNDLAK**	
	Est	**(robust se)**	**Est**	**(se)**	**Est**	**(se)**	**Est**	**(se)**
FIXED PART								
ln(net receipts)	0.085***	0.015	0.126*	0.071	0.095***	0.016	0.085***	0.016
ln(total claims)	0.051***	0.012	0.031	0.051	0.051***	0.012	0.051***	0.013
Secured creditors share	-0.071	0.071	0.028	0.373	-0.061	0.075	-0.071	0.077
BSA	0.227***	0.061	0.473	0.295	0.237***	0.060	0.227***	0.061
Bankruptcy estate	0.701***	0.049	0.758***	0.192	0.717***	0.045	0.701***	0.046
Contested creditors	-0.073	0.044	0.168	0.160	-0.058	0.041	-0.073*	0.042
Going Concern Sale	-0.459***	0.056	-0.174	0.234	-0.447***	0.059	-0.460***	0.057
Law (vs. 2010)								
2014	-0.352***	0.067	-0.151	0.180	-0.301***	0.472	-0.352***	0.049
2017	-0.688***	0.096	-0.089**	0.197	-0.574***	0.069	-0.688***	0.074
2018	-1.050***	0.077	-0.379	0.178	-0.898***	0.078	-1.050***	0.086

	(1) Within effects FE		(2) Between effects BE		(3) Random effects REML 2L		(4) Random effects plus clustered mean REML MUNDLAK	
	Est	(robust se)	Est	(se)	Est	(se)	Est	(se)
mean ln(net receipts)							0.068	0.067
mean ln(total claims)							0.016	0.049
mean Secured creditors							0.270	0.306
mean BSA							0.154	0.244
mean Bankruptcy estate							0.041	0.180
mean Contested creditors							0.254	0.156
mean Going Concern Sale							0.304	0.207
mean 2014							0.209	0.166
mean 2017							0.548***	0.189
mean 2018							0.652***	0.201
Constant	1.473***	0.185	0.765	0.921	1.262***	0.208	-0.328	0.843
RANDOM PART								
$\sqrt{\psi}$			0.274	0.036	0.277	0.034	0.218	0.032
$\sqrt{\theta}$	0.577		0.581	0.014	0.583	0.012	0.582	0.012
ρ				0.182		0.184		0.123
Number of observations		1337		1337		1337		1337
Number of judges		141		141		141		141

*Note: Dependent log months duration. For FE robust standard errors. Robust standard errors are not available with the REML option. The Kenward–Roger degrees of freedom correction were applied. * p < 0.10, ** p < 0.05, *** p < 0.01.*

The effect remains consistent across all model specifications. The presence of a bankruptcy estate continuation is associated with a 0.70 unit increase in logged case duration, equivalent to a 99.4% longer duration. This substantial increase underlines the substantial time burden imposed by post-primary estate management, often involving prolonged asset realization and creditor disputes. Conversely, cases resolved via a going-concern sale are associated with a 0.46 unit decrease in log-duration, equivalent to a 35.5% shorter duration. This aligns with theoretical expectations, as going concern sales often reflect more viable businesses and incentivize quicker resolution through structured negotiations. Regarding temporal effects, legal changes introduced in 2014, 2017, and 2018 are associated with successively shorter durations. Compared to the pre-reform period (2010 baseline), durations decreased by 29.7% in 2014, 49,8% in 2017, and 65.1% in 2018, all statistically significant.

Turning to the random part, the estimated standard deviation of judge-level random intercepts $\sqrt{\psi}$ in the model (4) is 0.218, with a residual error standard deviation $\sqrt{\theta}$ of 0.582. These translate into a between-judge variance of ψ = 0.044 and a within-judge (residual) variance of θ=0.339. The intra-class correlation coefficient is calculated as:

$$\rho(judge) = \frac{\psi}{\psi + \theta} = \frac{0.044}{0.044 + 0.339} = 0.123$$

The intraclass correlation coefficient suggests that 12.3% of the total variance in case duration is attributable to differences across judges. This implies that judge-level unobserved characteristics contribute non-trivial variation to case duration and provide empirical justification for the two-level modelling approach.

As stated, the likelihood-ratio test confirms the relevance of including random intercepts, while the Hausman test rejects the assumption of strict exogeneity of case-level predictors, supporting the use of the Mundlak correction. Notably, judge-level averages of certain predictors (e.g., contested creditors, BSA, going-concern sale) are statistically significant, indicating systematic differences in the types of cases handled by different judges. For example, the positive coefficient on mean contested creditors suggests that judges who typically handle more contentious cases preside over longer cases on average.

While not shown, an auxiliary model including sector dummies finds that only agriculture (Sector A) and construction (Sector F) are associated with significantly longer durations—approximately 27% and 33%, respectively—relative to the omitted category. Sectoral controls do not materially alter the core findings and offer limited additional explanatory power. As a robustness check, we estimated the model excluding 27 judges who presided over only one case (singleton clusters), which represent approximately 19% of all judges in the sample. The results remained almost identical in terms of fixed-effect coefficients, standard errors, and the intraclass correlation coefficient (ICC), indicating that the inclusion of singleton judges does not materially affect the findings. This confirms the stability and robustness of the main model specification.

Figure 1 presents a caterpillar plot of judge-specific random intercepts estimated from the mixed-effects model (Model 4). Each point represents an individual judge, ranked by their predicted deviation from the average (BLUP — Best Linear Unbiased Prediction), with 95% confidence intervals indicated by vertical lines. These Empirical Bayes estimates "shrink" individual judge effects toward the grand mean, with the degree of shrinkage depending on the amount of information (i.e., number of cases) available per judge and the variability in the data. The plot reveals substantial heterogeneity in judicial tendencies, with random intercepts ranging from approximately 0.6 to +0.5 in ln(months). This corresponds to case durations that are roughly 45% shorter to 65% longer compared to the average case duration, after controlling for case-level predictors. Judges with only a few cases show greater shrinkage toward zero and wider confidence intervals, reflecting the increased uncertainty in their individual estimates. While some confidence intervals do not overlap with zero, indicating potential between-judge differences, these should not be interpreted as formal significance tests due to the nature of BLUP estimation.

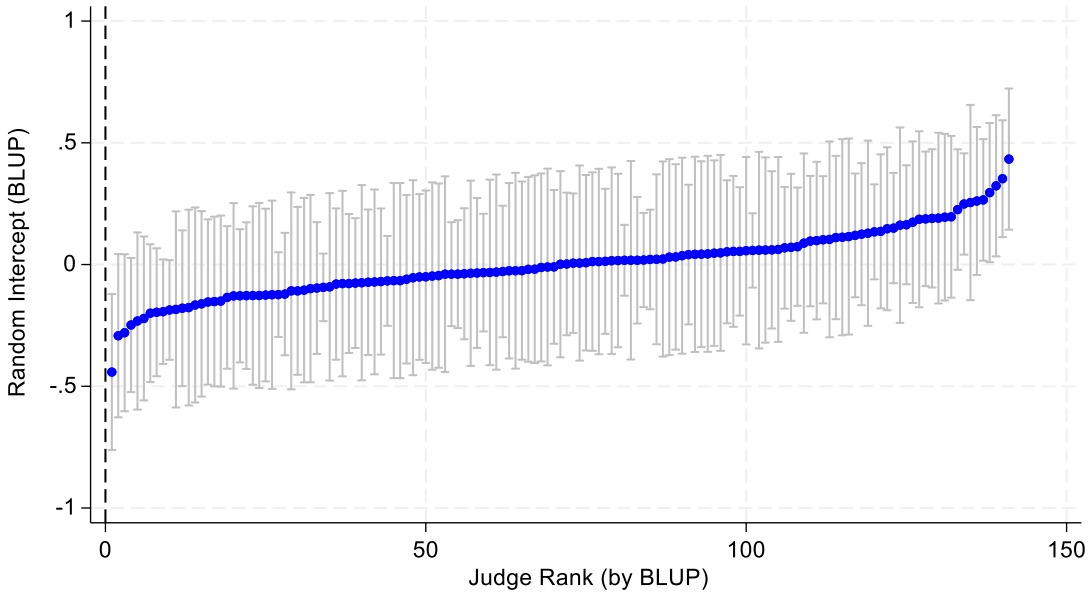


Figure 1. Caterpillar Plot of Judge Random Effects

In sum, the two-level random-intercept model reveals significant and robust differences in case duration attributable to individual judges, even after accounting for case-specific factors and legal context. The estimated intraclass correlation coefficient of 0.125 underscores the importance of unobserved judicial characteristics in shaping procedural efficiency. These findings validate the use of two-level modeling to account for hierarchical data structure and reinforce the relevance of judge-level variation in the design and evaluation of bankruptcy policy. In the next section, we extend the model to introduce court-level variation.

Three-Level Random-Intercept Model

Building on the two-level model presented earlier, we now extend the analysis to a three-level random-intercepts model, in which bankruptcy cases are nested within judges, and judges are further nested within courts. This expanded structure captures multiple layers of dependency in the data (see Figure 2) and allows us to disentangle not only case- and judge-level influences, but also broader court-level institutional variation.

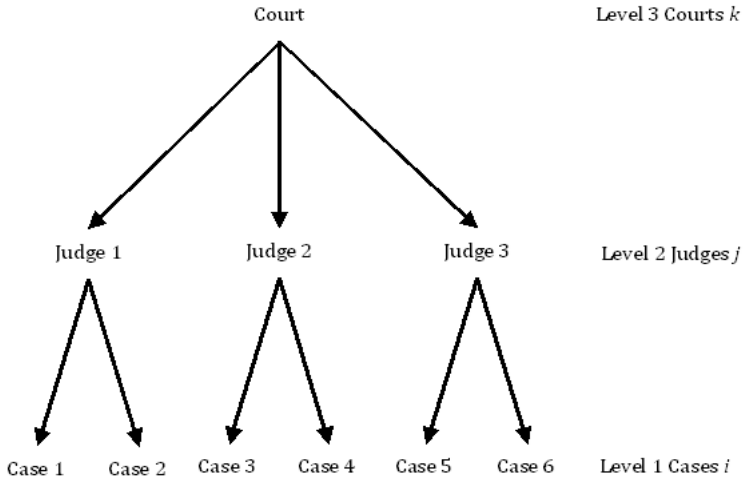


Figure 2. Three-level Model

Cases handled by the same judge are likely to exhibit correlated outcomes due to shared, unobserved characteristics such as the judge's decision-making approach, experience, or administrative efficiency. Likewise, judges operating within the same court are subject to common institutional factors, including resource constraints, administrative practices, and overall caseload management. By adopting a multilevel model, we are able to disentangle the variance in case outcomes attributable to case-specific attributes, judge-level heterogeneity, and broader court-level influences, thereby improving both the precision of estimation and the interpretability of results.

Formally, we specify the following three-level linear random-intercepts model (Rabe-Hesketh & Skrondal, 2022):

$$y_{ijk} = (\beta_1 + \zeta_{jk}^{(2)} + \zeta_k^{(3)}) + \beta_2 x_{1ij} + \cdots + \beta_p x_{pij} + \varepsilon_{ijk} \quad (5)$$

where:

- y_{ijk} is the outcome variable (case duration) for case i handled by judge j in court k,
- $x_{2ijk}, \ldots x_{pij}$ are case-level covariates,
- $\zeta_{jk}^{(2)} \sim N(0, \psi^{(2)})$ represents the judge-level random intercept (nested within court),

- $\zeta_k^{(3)} \sim N(0, \psi^{(3)})$ captures the court-level random intercept,
- $\varepsilon_{ijk} \sim N(0, \theta)$ is the case-specific residual.

This model allows us to decompose variation into three components: (1) within-judge, within-court (case-level) variation θ; (2) between-judge, within-court variation $\psi^{(2)}$; and (3) between-court variation $\psi^{(3)}$. A large $\psi^{(2)}$indicates significant differences between judges in the same court, while a large $\psi^{(3)}$ reflects substantial institutional variation across courts.

This model enables estimation of intra-class correlation coefficients at both the judge and court levels, offering insights into the hierarchical structure of variation and the institutional context shaping bankruptcy case outcomes. In the three-level model, for cases i and i'; within the same court but different judges j and j', the interclass correlation is:

$$\rho(court) = \frac{\psi^{(3)}}{\psi^{(2)}+\psi^{(3)}+\theta} \quad (5)$$

$$\rho(judge) = \frac{\psi^{(2)}+\psi^{(3)}}{\psi^{(2)}+\psi^{(3)}+\theta} \quad (6)$$

As in the two-level model, we assess the potential endogeneity of case-level predictors by applying the Mundlak correction, which augments the model with cluster-level means of level-1 covariates. In the three-level setting, we initially applied the correction at both the judge (Level 2) and court (Level 3) levels by including group means at each level. However, a likelihood ratio test comparing the full model (with both judge and court-level Mundlak terms) to a reduced model (judge-level only) found no significant improvement in model fit (LR $\chi^2(9) = 11.83$, $p = 0.223$). Thus, we retain only the judge-level Mundlak terms in the final model to maintain parsimony and theoretical coherence.

Since the fixed effects in the three-level model closely mirror those from the two-level specification, our discussion focuses primarily on the random part of the model, which provides new insights into the distribution of variance across judges and courts.

The estimated standard deviations of the random effects are as follows: 0.170 for judges within courts $\sqrt{\psi^{(2)}}$, 0.157 for courts $\sqrt{\psi^{(3)}}$, and 0.581 for the case-level residual variance $\sqrt{\theta}$. These values correspond to variance components of approximately 0.029 for judges, 0.025 for courts, and 0.338 for the residual. From these, we calculate the intra-class correlation coefficients (ICCs):

$$\rho(court) = \frac{\psi^{(3)}}{\psi^{(2)}+\psi^{(3)}+\theta} \approx 0.063, \qquad \rho(judge) = \frac{\psi^{(2)}+\psi^{(3)}}{\psi^{(2)}+\psi^{(3)}+\theta} \approx 0.136.$$

The decline in judge-level ICC from 19.6% (unadjusted) to 13.6% (Mundlak-adjusted) suggests that a substantial share of the between-judge variation in case duration arises from systematic differences in case composition, not merely unobserved judicial behavior.

In sum, the three-level model refines our understanding of hierarchical variance by quantifying how much of the observed case duration heterogeneity is driven by judges and courts. While court-level effects appear modest, judge-level variation remains significant even after accounting for case composition. This highlights the need for future research into the determinants of judicial behavior and potential institutional strategies to reduce disparities in bankruptcy case processing.

To account for procedural variation introduced by changes in legislation, we include dummy variables for the applicable version of the Bankruptcy Law. Most cases (71.10%) fall under the 2010 version of the law, with smaller shares under the 2014 (16.2%), 2017 (7.5%), and 2018 (5.4%) amendments. This distribution reflects the legal evolution of the bankruptcy framework in Serbia and enables us to assess whether legislative reforms had any measurable effect on the

duration of proceedings. However, it is important to note that a significant number of cases initiated under the 2017 and 2018 amendments were still ongoing at the time of data collection. As a result, these cohorts may be underrepresented in the sample of completed (closed) cases, potentially biasing observed duration estimates downward for more recent reforms. This should be kept in mind when interpreting the estimated effects of the 2017 and 2018 legal changes.

Table 3. Three-Level Model

	Random effects REML 3L		**Random effects plus clustered mean REML MUNDLAK**	
	Est	**(se)**	**Est**	**(se)**
FIXED PART				
ln(net receipts)	0.094***	0.016	0.085***	0.016
ln(total claims)	0.052***	0.012	0.051***	0.013
Secured creditors share	-0.087	0.076	-0.071***	0.077
BSA	0.231***	0.060	0.227***	0.061
Bankruptcy estate	0.704***	0.045	0.701*	0.047
Contested creditors dummy	-0.053	0.041	-0.073	0.042
Going Concern Sale	-0.443***	0.055	-0.461***	0.057
Law (vs. 2010)				
2014	-0.294***	0.047	-0.352***	0.049
2017	-0.556***	0.068	-0.689***	0.074
2018	-0.882***	0.077	-1.050***	0.086
mean ln(net receipts)			0.054	0.064
mean ln(total claims)			0.031	0.047
mean Secured creditors			0.049	0.317
mean BSA			-0.034	0.229
mean Bankruptcy estate			0.047	0.171
mean Contested creditors			0.169	0.151
mean Going Concern Sale			0.362	0.206
mean 2014			0.243	0.152
mean 2017			0.549***	0.174
mean 2018			0.681***	0.191
Constant	4.379***	0.229	-0.227	0.786
RANDOM PART				
$\sqrt{\psi^{(2)}}$	0.250	0.034	0.170	0.033
$\sqrt{\psi^{(3)}}$	0.139	0.044	0.157	0.040
$\sqrt{\theta}$	0.581	0.012	0.581	0.012
Number of observations	1377		1377	

Cross-Classified Random-Effect Model: Accounting for Bankruptcy Judge and Bankruptcy Administrator Interaction

Previous models assumed a hierarchical structure in which bankruptcy cases are nested within judges, and judges within courts. This structure presumes a strictly nested data-generating process—each judge is uniquely associated with a single court. However, one agent omitted from earlier models is the bankruptcy administrator. Administrators play a central role in the execution of insolvency proceedings. Their responsibilities include identifying and liquidating debtor assets, verifying creditor claims, and ensuring legal compliance. The competence and initiative of administrators can substantially influence case resolution times: while capable administrators may expedite proceedings, procedural errors or disorganization can lead to prolonged proceedings and increased costs.

Moreover, the interaction between judges and administrators is a potentially important but underexplored factor in procedural efficiency. Judges oversee legality and procedure, while

administrators carry out day-to-day operations. The degree of coordination and mutual responsiveness between these agents may affect overall case handling efficiency. Therefore, any comprehensive model of bankruptcy performance should capture not only the independent contributions of judges and administrators but also the possible effects of their collaboration.

To capture this more complex institutional structure, we specify a cross-classified random-effects model, in which both judges and administrators are treated as crossed (rather than nested) random effects. This specification reflects the reality that a single administrator may work with multiple judges, and vice versa. Cases are thus jointly classified by two distinct dimensions: the presiding judge and the appointed administrator. We limit our analysis to cases involving exactly one judge and one administrator, allowing us to avoid the additional complexity of a multiple membership model, which would require estimating membership weights (e.g., based on time contributions). While more flexible, such models can introduce measurement error and complicate estimation. The one-to-one assignment assumption keeps the model tractable while remaining theoretically sound.

In contrast to the earlier two-level hierarchical model, where cases were nested within judges and judges nested within courts, we do not include courts as an additional level in the crossed model. This choice is both theoretically and empirically justified. Empirically, the variance component associated with courts in the hierarchical model was negligible, suggesting that most of the explainable variation occurs at the judge level rather than being attributable to broader court-level institutional factors. Theoretically, once judges are modeled as individual random effects—capturing their procedural styles, workload management, and interpretive tendencies—little residual heterogeneity remains at the court level. Moreover, administrators are not nested within courts and may work across jurisdictions, making it difficult to incorporate courts into a crossed or hierarchical structure without misrepresenting the institutional realities of administrator assignment. Therefore, we omit courts from the crossed model to maintain parsimony and focus on the two key actors—judges and administrators—who directly shape procedural efficiency.

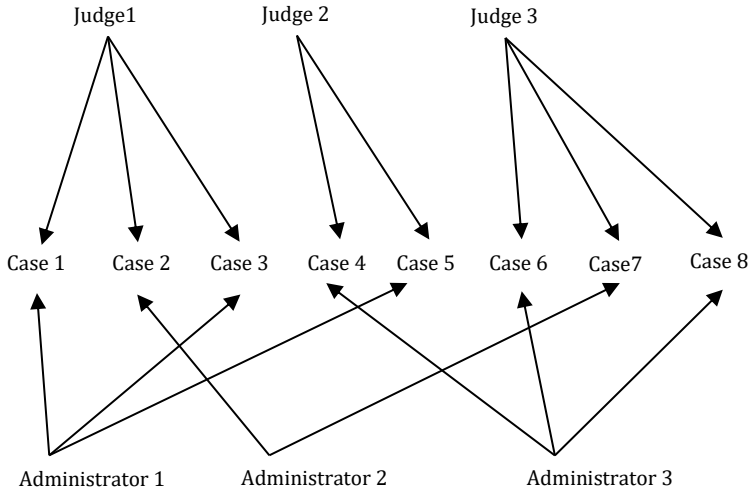


Figure 3. Cross-classified Data Structure

To estimate these effects, we begin with a model that includes only additive random effects for judges and administrators. In this framework, each actor contributes independently to the outcome of interest—in this case, the log of total case duration. The additive model captures systematic differences in case handling that can be attributed to individual judges and administrators, respectively.

The number of observations in the cross-classified estimate is reduced, as, similar to the case where judges may be substituted in individual instances, administrators can also be replaced. Accordingly, we identified an additional 114 cases where more than one administrator was involved. Approximately 39% of judge–administrator pairs appear in only one case, while the remaining 61% involve repeated combinations. This structure provides sufficient information to estimate a random interaction term, allowing us to assess whether certain judge–administrator pairs systematically deviate from their expected performance based on individual tendencies. Singleton pairs (pairs that occur only once) do not provide sufficient within-pair variation to estimate the interaction variance and are thus more heavily influenced by the overall mean due to empirical Bayes shrinkage.

It is also possible that certain specific pairings of judges and administrators perform differently than would be expected based solely on their individual effects. To account for this possibility, we extend the model by introducing a random interaction term between judges and administrators. This interaction term allows the model to capture unique dynamics within specific judge–administrator pairs, for example, more effective communication, mutual trust, or complementary work styles that result in higher efficiency.

The key distinction between the additive and interaction models lies in how they conceptualize influence. The additive model assumes that each actor has an independent and consistent effect on case duration, reflecting individual-level variation. In contrast, the interaction model allows for the possibility that certain pairings have idiosyncratic effects—positive or negative—that arise only in combination. While the additive model captures general tendencies, the interaction model tests whether some pairs perform differently together than would be expected based on their separate contributions.

We first specify the following additive crossed random-effects model (Rabe-Hesketh & Skrondal, 2022):

$$y_{ijk} = \beta_0 + \beta_1 x_{1ij} + \cdots + \beta_p x_{pij} + \zeta_{1j} + \zeta_{2k} + \varepsilon_{ijk} \quad (7)$$

- y_{ijk} is the log duration of case *i*, handled by administrator *j* and presided over by judge *k*,
- ζ_{1j} and ζ_{2k} additive (and uncorrelated) random effects for administrators and judges with zero means and variances $\psi_1$and ψ_2, respectively;
- ε_{ijk} residual represents the deviation of an individual case's efficiency from the mean for administrator *j* and judge *k*. For a given random set of effects, the residual has a mean of 0 and variance θ .

The implied intraclass correlations for two cases i and i' handled by the same administrator but different judges k and k' are:

$$\rho(administrator) = \frac{\psi_1}{\psi_1+\psi_2+\theta} \quad (8)$$

Similarly, the correlation between cases presided over by the same judge, but different administrators, is given by:

$$\rho(judge) = \frac{\psi_2}{\psi_1+\psi_2+\theta} \quad (9)$$

Finally, we can also examine the correlation between different cases presided over by the same judge and handled by the same administrator:

$$\rho(administrator, judge) = \frac{\psi_1+\psi_2}{\psi_1+\psi_2+\theta} \quad (10)$$

In many instances, the same judge–administrator combination appears in multiple cases. This structure raises the possibility that the pairing itself, not just the individual characteristics, affects efficiency. For instance, an administrator may be particularly effective when working with one judge, but less so with another, perhaps due to institutional familiarity or coordination practices. To capture such joint effects, we estimate an extended model with a random interaction term between administrators and judges:

$$y_{ijk} = \beta_0 + \beta_1 x + \cdots + \zeta_{1j} + \zeta_{2k} + \zeta_{3jk} + \varepsilon_{ijk} \quad (11)$$

In this specification, the term ζ_{3jk} represents a random interaction term between administrators and judges in the model. The random interaction term ζ_{3jk} has a mean of 0 and variance ψ_3 and it is uncorrelated with the other random terms (ζ_{1j}, ζ_{2k} and ε_{ijk}), and also uncorrelated across combinations of judges and administrators.

The corresponding intraclass correlations in this specification become:

$$\rho(administrator) = \frac{\psi_1}{\psi_1+\psi_2+\psi_3+\theta} \quad (12)$$

For cases handled by the same administrator j but presided over by different bankruptcy judges k and k', the interaction term $\psi_3 = 0$ if there is no interaction:

$$\rho(judge) = \frac{\psi_2}{\psi_1+\psi_2+\psi_3+\theta} \quad (13)$$

For cases i and i' presided over by the same judge k, but handled by different administrators j and j', the correlation is given by:

$$\rho(administrator, judge) = \frac{\psi_1+\psi_2+\psi_3}{\psi_1+\psi_2+\psi_3+\theta} \quad (14)$$

The results presented in Table 4 summarize the restricted maximum likelihood estimates from two specifications of the crossed random-effects model: an additive model with random effects for judges and administrators, and an interaction model that additionally includes a random effect for judge–administrator pairings.

Table 4. Restricted Maximum Likelihood (REML) Estimates for Crossed Random-Effects Models

	Additive		**Interaction**	
	Est	**(se)**	**Est**	**(se)**
ln(net receipts)	0.078***	0.016	0.077***	0.016
ln(total claims)	0.054***	0.013	0.055***	0.013
Secured creditors share	-0.133*	0.078	-0.130*	0.078
BSA	0.240***	0.061	0.239***	0. 062
Bankruptcy estate	0.686***	0.048	0.682***	0.045
Contested creditors dummy	-0.053	0.042	-0.050	0.042
Going Concern Sale	-0.410***	0.057	-0.410***	0.057
Law (vs. 2010)				
2014	-0.360***	0.051	-0.361***	0.051
2017	-0.659***	0.075	-0.660***	0.075

	Additive		Interaction	
	Est	**(se)**	**Est**	**(se)**
2018	-1.037***	0.086	-1.039***	0.086
Control variables (means)	included		included	
Constant			-0.531	0.776
$\sqrt{\psi_1}$ (Administrator)	0.241	0.026	0.103	0.071
$\sqrt{\psi_2}$ (Judge)	0.161	0.034	0.159	0.034
$\sqrt{\psi_3}$ (Administrator, Judge)			0.235	0.026
$\sqrt{\theta}$	0.530	0.773	0.531	0.776
Restricted log likelihood	-1202.95		-1142.563	
LR test vs. linear model	78.32		78.88	
Number of judges	141		141	
Number of administrators	310		310	
Number of observations	1263		1263	

*Note: Estimates marked with ***, **, * are statistically significant at the 1%, 5% and 10% level, respectively.*

The results of both models confirm findings from the previous section. Size indicators (net receipts and total claims), socially owned companies, as well as the establishment of the bankruptcy estate through going-concern sales, have the expected prolonged effect on the duration of bankruptcy cases. Hence, we will focus on the other part of the results.

The intraclass correlation coefficients (ICCs) derived from both additive and interaction cross-classified models consistently underscore the dominant role of administrators compared to judges in explaining outcome variation. In the additive model, administrators account for approximately 15.6% of the total variance, while judges explain only 7.0%, underscoring the stronger influence of administrators on case-level outcomes. When the model allows for interaction effects between administrators and judges, the administrator-specific variance remains relatively stable at 14.9%, and the judge-related variance slightly decreases to 6.8%. Notably, the combined variance attributed to administrator and judge effects, including their interactions, increases to 24.5% in the interaction model, compared to 22.6% in the additive specification. This suggests that outcomes are not only shaped by individual roles but also by the specific administrator–judge pairings involved in a case. Taken together, these results point to the administrator as the more dominant actor in the decision-making process, and they indicate that the relational context between administrators and judges may further influence outcomes in meaningful ways.

Table 5. Estimated interclass correlations for Crossed Random-Effects Models

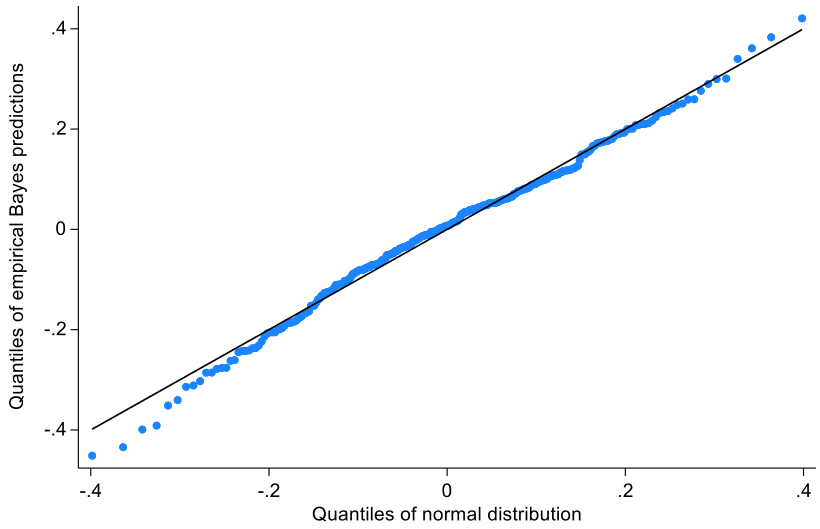
Component	Additive Model ICC	Interaction Model ICC
$\rho(administrator)$	0.156	0.149
$\rho(judge)$	0.070	0.068
$\rho(administrator, judge)$	0.226	0.245

To evaluate the necessity of random effects, we performed a likelihood-ratio test comparing the crossed random-effects model to a standard linear regression. The resulting test statistic (LR = 123.29) strongly rejects the null hypothesis that all variance components are zero, confirming that unobserved heterogeneity at the judge and administrator levels is meaningful. We then tested whether the random interaction term was required. The LR statistic (χ^2 = 0.57, p = 0.4518) was not significant; after adjusting the p-value for boundary conditions, the result (p ≈ 0.226) still fell short of conventional significance levels. We thus retain the additive specification as the more

parsimonious model, while acknowledging that the interaction model captures modestly greater variance (24.5% vs. 22.6%).

As the hypothesis tests conducted above suggested that a random interaction was not required, we use the crossed random-effects model without an interaction. Finally, we obtain empirical Bayes predictions of both the administrator and judge random effects. If the random effects and the level-1 residual are assumed to have normal distributions, these predictions should have normal distributions. Both in the case of administrators and the case of judges, predictions have distributions that are very close to normal (Figure 4), with several outlying judges and administrators.

(a) Administrator predictions



(b) Judge predictions

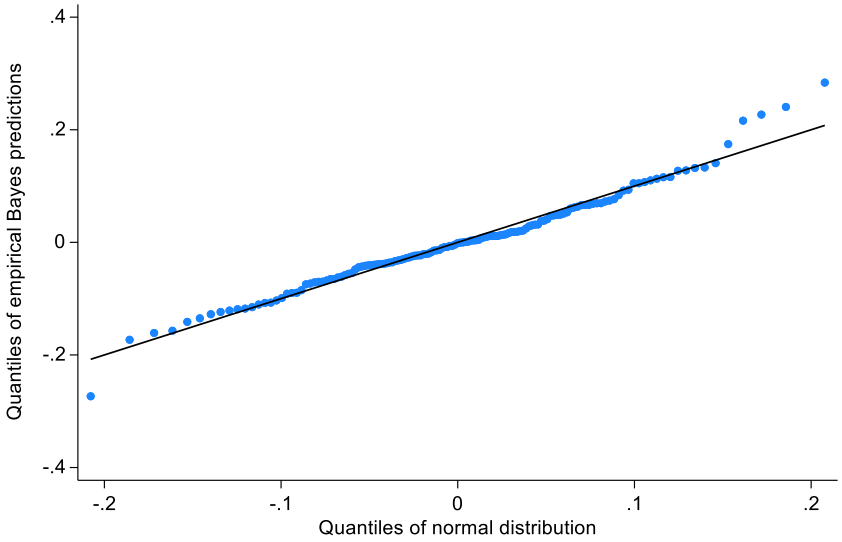


Figure 4. Normal Q–Q plots

This analysis underscores the importance of both judges and administrators in enhancing procedural efficiency. While judges provide legal oversight, administrators exert a stronger operational influence. The ICCs suggest that both roles contribute meaningfully to case variation,

with administrators exerting greater systematic influence. Although the interaction model captures additional variation by modeling specific judge–administrator pairings, the additive specification suffices in explaining most of the observed differences. These findings support a modeling approach that accounts for the independent, and occasionally synergistic, effects of key institutional actors.

CONCLUSION

This study provides empirical evidence on the critical roles that both bankruptcy judges and administrators play in determining the efficiency of bankruptcy proceedings, with case duration serving as a key performance metric. Using hierarchical and cross-classified random-effects models applied to over 1,300 Serbian bankruptcy liquidation cases, the analysis demonstrates the utility of multilevel modeling in isolating actor-specific effects while controlling for a range of case-level characteristics. The estimated effects of covariates align with expectations: larger bankruptcy estates, involvement of socially owned companies, and BSA oversight are associated with longer case durations, reflecting procedural complexity and heightened scrutiny, while going-concern sales significantly reduce duration, likely due to greater incentives for expedited resolution.

The analysis shows that judges, courts, and administrators all influence procedural efficiency in bankruptcy cases. Administrators have the largest impact on case duration by managing insolvency operations like asset liquidation, claim verification, and legal compliance. Judges consistently affect outcomes, albeit to a smaller extent, while courts contribute to institutional procedural variation due to different practices and resource constraints. These findings highlight the importance of considering individual roles, institutional context, and interactions in bankruptcy cases.

Future research should explore other aspects of bankruptcy efficiency, like recovery rates or costs. This study effectively uses hierarchical and cross-classified models on a detailed dataset, but it has limitations. Specifically, it lacks data on judges' and administrators' backgrounds, such as their experience, caseload, tenure, or affiliations. This omission prevents us from distinguishing personal, procedural, and contextual influences on performance. While case-level factors are controlled, without agent-level data, linking variance to specific traits is challenging. Future studies should include agent-level data to provide clearer insights and policy recommendations.

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