sciendo

Data-driven proactive contracting: a mathematical framework for enhancing strategic agility, risk management and value creation

Mohammad Naji Shah Mohammadi

Department of Business Law
University of Vaasa
Wolffintie 32
Vaasa 65200, Finland
najishah@uwasa.fi

Azam Pirmoradian

NielsenIQ
Nielsen House, John Smith Drive
Oxford OX4 2WB, UK
azam.pirmoradian@gmail.com

Foad Shokrollahi

Department of Mathematical and Statistical Modelling
University of Vaasa
Wolffintie 32
Vaasa 65200, Finland
foad.shokrollahi@uwasa.fi

Peiman Pirmoradian

Pundit, Ltd.
Grovelands Rd.
Oxford OX3 8HZ, UK
don.pirmorad@gmail.com

Abstract: Traditional contracts assume that all future contingencies can be anticipated and explicitly addressed at the outset. However, due to uncertainty, information asymmetry and evolving business conditions, contracts inevitably leave gaps, limiting their ability to function as effective governance tools. While amendment clauses offer a means for adjustments, they fail to resolve complexities related to risk quantification, strategic flexibility and real-time adaptation. Grounded in proactive contracting, this paper presents a methodological framework that redefines contracts as dynamic, data-driven governance mechanisms. By integrating real-time data analytics, stochastic forecasting and multi-objective optimization, the framework enables contracts to anticipate risks, optimize trade-offs and continuously adjust to shifting market conditions. This research advances contract governance by demonstrating how adaptive contracts can move beyond static enforcement to actively support business resilience, sustainability and long-term value creation. By embedding structured adaptability, the study provides a transformative approach to ensuring that contracts remain strategically aligned, legally enforceable and responsive to uncertainty in modern business environments.

Keywords: *data-driven governance, multi-objective optimization, proactive contracting, risk management, strategic adaptability*

1. Introduction

Contracts have traditionally been regarded as legal instruments designed to mitigate risk, ensure compliance and formalize the rights and obligations of contracting parties (Jolls, 1997). However, this static, reactive perspective often fails to align with the complexity and dynamism of modern business environments (Haapio, 2006; Nystén-Haarala, 2006). With technological advancements, evolving global markets and shifting stakeholder expectations, contracts must move beyond rigid legal enforcement to function as adaptive governance tools (Barton *et al.*, 2021; Cummins, 2015). Increasingly, both scholars and practitioners advocate for contracts that not only provide legal certainty but also enhance strategic agility, foster innovation and support sustainable business practices (Berger-Walliser, Bird and Haapio, 2011; Haapio, deRooy and Barton, 2018; Siedel and Haapio, 2010). This shift reflects the growing recognition that contractual governance must be proactive, ensuring long-term business resilience and competitive advantage (Solarte-Vásquez and Nyman-Metcalf, 2017).

To address these challenges, this study presents a methodological framework that integrates legal scholarship and mathematical modeling to develop data-driven proactive contracting. Rather than incorporating specific technologies, this framework provides a structured approach to enhancing contract adaptability by applying rigorous quantitative and legal methodologies. Building upon insights from contemporary contract governance approaches, it moves beyond traditional compliance-driven models toward more strategic, dynamic and data-responsive structures. By leveraging three core analytical techniques—real-time data analytics, stochastic forecasting and multi-objective optimization—the framework enables contracts to systematically adjust to evolving business conditions while maintaining legal enforceability. Legal governance principles ensure that contract adaptability, risk allocation and compliance mechanisms remain robust and aligned with business objectives (Farhadali, 2024). By incorporating mathematical analysis, the study offers a structured means of balancing efficiency, risk resilience and strategic alignment, ensuring that contracts remain responsive and optimized within complex business environments.

The framework leverages three core analytical techniques to operationalize adaptive contract governance. First, real-time data analytics enables contracts to process and analyze continuous information streams, allowing for early detection of risks, trend identification and immediate decision-making (Jarunde, 2023). By integrating structured data from diverse sources—such as market conditions, operational performance and legal compliance—contracts can dynamically adjust to emerging challenges and opportunities. Second, stochastic forecasting applies probabilistic modeling to assess the likelihood of uncertain events, ensuring that contracts incorporate risk anticipation rather than reactive enforcement (Rubin and Patel, 2017; Abi Jaber and Villeneuve, 2025). This enhances contractual resilience by allowing for structured adjustments before disruptions occur, reducing negotiation costs and legal disputes. Third, multi-objective optimization systematically balances competing contractual goals—such as cost efficiency, risk mitigation, performance incentives and sustainability commitments (Sharma and Kumar, 2022). This ensures that contract governance is not solely compliance-driven but strategically aligned with long-term business objectives.

By integrating these techniques, the framework moves beyond traditional contract structures, which often rely on fixed clauses and static enforcement mechanisms (Nystén-Haarala, 2006). Instead, contracts evolve into dynamic instruments that continuously align with business priorities while remaining legally enforceable and strategically adaptable (Griffo *et al.*, 2023). This methodological foundation is designed for scalability, ensuring that contracts across different industries and regulatory landscapes can benefit from structured adaptability. By bridging legal reasoning with mathematical optimization, the framework advances contract governance research, demonstrating how contracts can actively support business resilience, innovation and long-term value creation.

Ultimately, this approach redefines contracts as proactive governance mechanisms that integrate legal, managerial and technological perspectives to support business flexibility and sustainable growth. By embedding data-driven insights, predictive modeling and structured decision-making, contracts become strategic enablers of business success, ensuring that legal governance is not merely reactive but continuously aligned with evolving market realities.

2. Theoretical framework of proactive contracting

Proactive contracting represents a fundamental evolution in contract governance, shifting contracts from static legal instruments to dynamic, strategic tools that foster adaptability, collaboration and long-term value creation (Saloranta and Hurmerinta-Haanpää, 2023, p. 3). Rooted in proactive law, which reimagines legal systems as integrated components of broader economic and operational ecosystems, proactive contracting builds on the foundational principles of strategic foresight, risk anticipation and business-oriented legal mechanisms (Pohjonen, 2006). It ensures that contracts not only mitigate risks but also enable innovation, trust-building and alignment with broader business objectives (Rekola and Haapio, 2011; Hurmerinta-Haanpää and Berger-Walliser, 2024).

To understand the role of proactive contracting in modern governance, it is essential to examine its key theoretical foundations. The theory of incomplete contracts highlights that contracts cannot account for all possible contingencies due to uncertainty, information asymmetry and bounded rationality (Hart, 2017; Frydlinger and Hart, 2023). While this theory suggests that contractual gaps are inevitable, proactive contracting mitigates their impact by emphasizing structured foresight, flexibility and governance mechanisms that reduce uncertainty and enable strategic, rather than reactive, decision-making (Berger-Walliser, Bird and Haapio, 2011).

Another significant perspective is relational contract theory, which shifts the focus from strict legal enforcement to trust, cooperation and mutual adjustment in sustaining long-term business relationships (Feinman, 2024; Macneil, 1978). While traditional contracts often emphasize rigid enforcement mechanisms, relational contracting underscores the role of trust, collaboration and shared value creation (Frydlinger, Hart and Vitasek, 2019). Proactive contracting aligns with relational principles by prioritizing collaboration and adaptability, yet formalizing these relational dynamics remains a challenge (Cummins, 2025).

The importance of structured governance also aligns with transaction cost economics (TCE), which explains how firms structure contracts to optimize efficiency and minimize uncertainty-driven costs (Williamson, 1979). Proactive contracting inherently seeks to enhance contractual efficiency and business resilience, and structured decision-making plays a crucial role in maintaining this balance (Rekola and Haapio, 2011). By reducing unnecessary renegotiations and inefficiencies, fostering adaptability and providing structured mechanisms for managing change, proactive contracting enables firms to respond more effectively to evolving conditions while minimizing the burdens of contract revisions. This enhances cost-effectiveness while maintaining governance efficiency, ensuring that contractual structures remain resilient in volatile business conditions.

The dynamic capabilities theory further reinforces the need for proactive contracting, emphasizing that organizations must continuously adapt their contractual frameworks to sustain competitive advantage in evolving market conditions (Teece, Pisano and Shuen, 1997). As businesses navigate increasing complexity, contracts must not only serve as governance tools for managing risk and ensuring compliance but also as dynamic mechanisms that enable strategic flexibility and long-term resilience (Pohjonen, 2006). In this regard, proactive contracting aligns with dynamic capabilities theory by ensuring that contracts remain adaptable, responsive to external changes and strategically aligned with business objectives (Cummins, 2015; Solarte-Vásquez and Nyman-Metcalf, 2017, pp. 211, 213).

However, in an era where businesses face growing societal and environmental expectations, shared value theory (SVT) further extends the rationale for proactive contracting by emphasizing that long-term business success is deeply interconnected with societal progress (Porter and Kramer, 2018). SVT argues that firms can create sustainable economic value by embedding societal and environmental objectives within their core strategies, rather than treating them as external obligations. Contracts, as governance instruments, play a pivotal role in operationalizing this principle—ensuring that commitment to sustainability, ethical practices and stakeholder collaboration are not just aspirational but enforceable and measurable within business operations (Hurmerinta-Haanpää and Berger-Walliser, 2024; Saloranta and Hurmerinta-Haanpää, 2022). By integrating dynamic capabilities theory and shared value theory, proactive contracting emerges as a strategic enabler that not only ensures adaptability and risk mitigation but also aligns contractual frameworks with the broader objectives of sustainable innovation, trust-building and long-term value creation.

3. Framework characteristics and mathematical foundations of proactive contracting

Traditional text-based contracts assume that all future contingencies can be anticipated and explicitly addressed at the outset (Nystén-Haarala, 2006). However, real-world contracting is inherently uncertain due to evolving external factors, information asymmetry and unpredictable market conditions (Frydlinger and Hart, 2023). While amendment clauses provide a legal mechanism for modifications, they often fail to address the complexities of strategic flexibility, risk quantification and real-time adaptation (Nystén-Haarala, Lee and Lehto, 2010). Mathematical and optimization-based frameworks offer a structured approach to mitigating these limitations by embedding adaptive mechanisms into contract structures. These models enable contracts to dynamically respond to changing business environments while maintaining both legal enforceability and strategic flexibility.

As markets fluctuate, regulations evolve and stakeholder expectations shift, contractual governance must transition from static legal instruments to dynamic, predictive and responsive frameworks (Fang *et al.*, 2024). Traditional contract structures, which rely on fixed clauses and reactive amendments, often struggle to accommodate real-time changes, increasing transaction costs and legal uncertainty—especially in industries requiring continuous contract adaptation (Kostritsky, 2019). To address these challenges, mathematical and optimization-based frameworks enhance real-time adaptability, precision and decision-making under uncertainty (Bertsimas and Thiele, 2006). Rather than replacing existing contractual flexibility mechanisms, these frameworks reinforce them by integrating predictive analytics, structured optimization and algorithmic decision-making. This reduces the need for frequent renegotiations while improving contract responsiveness to evolving business conditions.

Mathematical frameworks further enhance proactive contracting by structuring decision-making processes that optimize adaptability, risk management and value creation. A well-structured contract leverages multi-objective optimization and predictive modeling to dynamically adjust key terms based on predefined parameters, ensuring that governance processes remain responsive and strategically aligned. This adaptive mechanism extends to modifying pricing structures, delivery schedules, risk-sharing models and performance benchmarks—not only to accommodate market fluctuations and regulatory shifts but also to integrate broader strategic business objectives, such as sustainability goals, long-term resilience and stakeholder alignment. By balancing multiple, often competing priorities—including cost efficiency, risk mitigation, environmental impact and operational performance—contracts evolve from static legal instruments into dynamic governance tools. This structured adaptability ensures that contractual frameworks remain agile, enforceable and strategically positioned to support both short-term operational efficiency and long-term business sustainability while minimizing disruptions and fostering innovation.

Recent studies have advanced the integration of mathematical optimization frameworks into proactive contracting, particularly in project scheduling and management. Davari and Demeulemeester (2019) addressed the resource-constrained project scheduling problem under uncertain activity durations by proposing an integrated proactive–reactive scheduling approach. Their model formulates a combined cost function encompassing baseline schedule costs and reaction costs, demonstrating improved stability and robustness compared to traditional methods. Similarly, Li, He and Wang (2023) developed a branch-and-bound algorithm to maximize robustness in proactive resource-constrained project scheduling. Their approach resolves resource conflicts by introducing additional precedence relationships, reducing computational time and enhancing project robustness. A recent 2024 study proposed a two-phase framework integrating proactive and reactive strategies to manage disruptions in multi-mode resource-constrained project scheduling (Khoshsirat and Mousavi, 2024). The proactive phase develops a resilient baseline schedule, while the reactive phase employs strategies like preempt-repeat, preempt-resume and activity-crashing to mitigate disruption impacts. This approach, validated through a real-world case study in the oil and gas sector, highlights its effectiveness in minimizing project delays and costs. These studies collectively underscore the efficacy of mathematical optimization in enhancing project scheduling resilience and efficiency through proactive contracting strategies.

Despite significant progress in integrating mathematical optimization into proactive contracting, gaps remain in applying multi-objective optimization frameworks. Most existing studies focus on minimizing project delays or maximizing robustness but often treat cost and risk management as separate objectives rather than integrating them into a unified decision-making process. Additionally, sustainability factors, such as environmental impact and long-term resilience, are rarely incorporated. The inclusion of stochastic forecasting could further enhance these models by leveraging real-time data analytics to anticipate uncertainties and dynamically adjust contract parameters. A holistic approach that balances cost efficiency, risk mitigation, sustainability and real-time adaptability through multi-objective optimization would provide a more comprehensive framework for proactive contracting.

By synthesizing these theoretical perspectives and mathematical modeling principles, proactive contracting emerges as a comprehensive framework for modern contract governance. As organizations navigate growing complexities, transitioning contracts from rigid legal agreements to adaptive governance tools becomes essential for sustaining long-term business resilience and competitive advantage. The evolution of contracts from static legal instruments to dynamic, multi-dimensional governance assets highlights the increasing necessity of integrating predictive, data-driven strategies into contractual frameworks, ensuring they remain legally sound, strategically agile and aligned with evolving business realities.

4. Mathematical foundations of the proposed framework

This framework introduces a structured mathematical approach that enables contracts to dynamically adjust in response to real-time data. By integrating stochastic forecasting and multi-objective optimization, this approach enhances contract resilience, moving beyond rigid legal enforcement mechanisms toward proactive and data-driven decision-making.

Dynamic contract adjustments using real-time data

A contract's ability to remain relevant and enforceable depends on its capacity to adapt to external fluctuations. In this framework, contract terms X(t) evolve as functions of real-time variables:

$$X(t) = f(D(t),M(t),E(t))$$

where:

- $D(t)$ marks real-time operational data (e.g., demand levels, supply chain efficiency);
- $M(t)$ represents market-driven conditions (e.g., competitor pricing, inflation rates);
- $E(t)$ indicates external events (e.g., regulatory updates, geopolitical shifts).

This structure ensures that contracts respond dynamically, reducing the risks associated with fixed clauses and manual renegotiations.

Managing uncertainty through stochastic forecasting

Uncertainty is an inherent challenge in contract governance, particularly in pricing, supply chains and regulatory compliance. The framework integrates stochastic modeling to quantify these uncertainties, improving predictive accuracy and minimizing disruptions. Price fluctuations, for instance, can be modeled as:

$$dp(t) = \mu p(t)dt + \delta p(t)dz(t)$$

where:

- $p(t)$ represents the contractually relevant variable at time t (e.g., pricing, service performance);
- μ accounts for long-term expected trends;
- δ captures short-term volatility;
- $dz(t)$ represents unpredictable market fluctuations.

By embedding probabilistic risk anticipation, contracts incorporate proactive adjustments, reducing exposure to sudden economic shifts or supply chain disruptions.

Optimizing contract performance through multi-objective decision-making

Contracts must balance multiple competing objectives to remain strategically aligned with business and legal priorities. This framework employs multi-objective optimization, ensuring that contracts systematically adjust to trade-offs between key business goals, such as:

$$min(w_c C(X)+w_R R(X) - w_P P(X) - w_S S(X) - w_T T(X))$$

where:

- *C(X)* represents cost function, representing total expenditures;
- *R(X)* marks risk function, derived from stochastic modeling;
- *P(X)* represents profit function, representing revenues and margins;
- *S(X)* is sustainability function, assessing environmental impact;
- *T(X)* marks trust function, measuring relational stability.

Constraints are applied to maintain contract feasibility and enforceability:

$$C(X) \leq B$$

$$P(R(X) \leq R_{max}) \geq 0.95$$

$$S(X) \leq S_{max}$$

The probability constraint ensures that the risk (or sustainability metric) remains within an acceptable threshold, rather than being an absolute maximum. This approach allows for controlled risk-taking while maintaining contractual feasibility. *Rmax* represents a predefined acceptable risk limit, not an absolute maximum, and similarly, *Smax* defines an upper sustainability threshold. This ensures that the probability of exceeding these limits remains below a specified confidence level (e.g., 95%), providing a structured way to manage uncertainties in contract performance. By embedding real-time optimization, this framework enhances contractual efficiency while maintaining business and regulatory compliance.

Scenario-based optimization for contract resilience

The framework also employs scenario-based stochastic optimization, generating multiple potential business scenarios rather than relying on a single projected future. This approach minimizes:

$$E[C(X)] + \lambda Var[P(X)]$$

where λ represents a risk-adjustment factor, allowing flexibility to prioritize either stability or profitability.

By incorporating real-time data, risk anticipation and structured decision-making, contracts transition from passive legal safeguards to proactive governance mechanisms, ensuring they remain effective under evolving business conditions.

Illustrative example: applying the optimization model in supply chain contracts

To illustrate the practical application of this optimization model, consider a hypothetical scenario in supply chain management involving TechMart, a multinational electronics retailer, and ElecParts Inc., a semiconductor manufacturer. Their contract is no longer a static legal document but a strategic, data-driven agreement that continuously adapts to real-time conditions. By integrating real-time analytics, predictive modeling, multi-objective optimization and structured adaptability, the contract ensures that business objectives, financial risks, operational efficiency and sustainability commitments remain dynamically aligned.

As market conditions shift, multiple forces—demand fluctuations, raw material price volatility, logistical inefficiencies and evolving sustainability requirements—interact, requiring a multi-level decision-making approach. Traditional contracts would demand reactive renegotiations, leading to inefficiencies and disputes. Instead, the dynamic contract framework, powered by real-time data analytics and forecasting, allows simultaneous adjustments to pricing, supply commitments and compliance incentives, ensuring optimal outcomes.

The contract continuously pulls live data from demand forecasts, supplier capacity reports, commodity pricing indexes, logistics metrics and carbon emissions tracking. This feeds into a predictive analytics model, which anticipates demand surges, cost fluctuations and supply chain risks. Rather than waiting for disruptions, the contract recalibrates pricing mechanisms, risk-sharing strategies and sustainability measures in advance.

For instance, a 50% surge in semiconductor demand is detected through global market trends and sales patterns, prompting an automatic production scale-up while preventing overcommitment. Simultaneously, pricing adjustments and inventory reserves are optimized, ensuring supply constraints do not inflate costs or disrupt deliveries.

When raw material costs rise by 20%, the contract's multi-objective optimization model redistributes cost burdens, dynamically adjusting pricing terms based on global pricing trends and procurement history, ensuring mutual financial stability.

At the same time, logistical inefficiencies—such as shipping lane backlogs—trigger automated contract adjustments to delivery schedules, production timelines and alternative shipping routes, preventing stock shortages and financial penalties.

Sustainability commitments are fully integrated. A major buyer mandates a 15% carbon reduction for suppliers to retain preferred vendor status. The contract tracks ElecParts' carbon footprint in real time, adjusting sourcing preferences and transport logistics to lower emissions. If ElecParts invests in sustainable technology, the contract recalculates cost structures, rewarding compliance with better pricing terms or contract extensions. Instead of treating sustainability as an afterthought, the contract aligns environmental goals with financial and operational strategies, turning compliance into a competitive advantage.

5. Additional considerations

Despite the advantages of mathematical and optimization-based models, automated contractual mechanisms face key challenges, including regulatory uncertainty, data biases and the complexity of coding nuanced, context-dependent obligations. While these models significantly enhance contractual adaptability, they also introduce new complexities that must be carefully managed. Over-reliance on quantitative models could result in rigid, overly algorithmic governance structures where contracts fail to account for relational dynamics and evolving business priorities. Additionally, the computational demands of multi-objective optimization may make real-time adaptation resource-intensive, particularly for organizations with limited access to high-quality data and analytics capabilities.

One of the critical challenges in contract optimization is the precise measurement of competing objectives, including risk mitigation, cost efficiency, performance, sustainability and relational stability. Effective multi-objective optimization relies on quantifiable metrics, yet many of these objectives—particularly those related to trust, collaboration and long-term value creation—are inherently difficult to measure. Future research should focus on developing robust evaluation frameworks and methodologies to enhance the accuracy of these measurements, ensuring that contract optimization remains both practical and strategically aligned with business goals.

For legal professionals, the integration of quantitative governance methodologies does not replace traditional legal expertise but rather complements and enhances legal reasoning. Contracts are increasingly expected to function as both legal safeguards and strategic assets, requiring proactive, data-driven decision-making rather than a purely compliance-focused approach. However, as optimization models gain wider adoption, legal experts will need to develop interdisciplinary competencies, engaging with predictive modeling, algorithmic risk assessment and adaptive compliance mechanisms. The success of these models will depend on how well they are integrated into legal frameworks and whether they strike the right balance between automation, flexibility and human discretion.

This research opens the door to linking legal expertise with mathematical modeling, creating a clear roadmap for utilizing emerging technologies in contract design and governance. While this study focuses on the foundational integration of these approaches, future research should explore how emerging technologies—such as AI, blockchain and advanced analytics—can further enhance the adaptability, transparency and efficiency of contracts. The potential for leveraging real-time data and automated decision-making within legal frameworks remains vast, requiring ongoing exploration into the best ways to align these technologies with business strategy, regulatory requirements and ethical considerations.

Thus, while mathematical and optimization-based approaches represent a major advancement in contract governance, they are not a one-size-fits-all solution. Rather, they offer a structured, adaptable methodology that can improve decision-making, reduce inefficiencies and enhance contractual resilience in complex and uncertain environments. Future research and practice should focus on refining these models, ensuring their adaptability across different industries and addressing the legal and ethical implications of increased automation in contracting. By transitioning contracts from static legal documents to dynamic, data-driven governance mechanisms, these models contribute to the ongoing evolution of contracting—but their success will ultimately depend on careful design, real-world testing and the ability to balance mathematical precision with legal and relational considerations.

6. Conclusion

This research redefines contract governance by transitioning contracts from static legal instruments to dynamic, multi-dimensional assets that actively support business strategy, resilience and long-term value creation. By integrating proactive contracting principles with mathematical modeling, stochastic forecasting and multi-objective optimization, this study presents a structured framework for adaptive, data-driven contracting.

Through real-time analytics and predictive decision-making, contracts can dynamically adjust to evolving business conditions, balancing risk mitigation, performance optimization, relational stability and sustainability commitments. This approach not only enhances contractual efficiency but also ensures that legal structures remain strategically aligned with modern business complexities.

The findings of this research offer a practical foundation for organizations seeking to implement adaptive contracting mechanisms. However, the successful adoption of this framework will depend on overcoming challenges related to data quality, computational feasibility and regulatory alignment. Future research should focus on refining optimization models for industry-specific applications, integrating emerging AI-driven contract mechanisms and exploring the legal and ethical implications of algorithmic contract governance. By advancing the intersection of law, technology and business strategy, this study contributes to the ongoing evolution of contracts as strategic enablers of innovation, resilience and sustainable growth.

Mohammad Naji Shah Mohammadi is a doctoral researcher in business law at the University of Vaasa, Finland, specializing in strategic contract management and proactive legal strategy. His research focuses on repositioning legal frameworks as strategic business assets that drive innovation, governance and long-term value creation. With a background in law and business, Naji integrates legal foresight with business strategy to explore how legal mechanisms can enhance sustainability, competitiveness and corporate resilience.

Azam Pirmoradian has over ten years of experience in data analysis and optimization, working in the R&D department of NIQ. With a PhD in statistics and optimization, their research focuses on applying mathematical modeling, predictive analytics and machine learning to solve complex business challenges. Their expertise lies in developing

data-driven frameworks for strategic decision-making, with a particular interest in contract optimization, risk management and real-time data applications.

Foad Shokrollahi is a university lecturer (associate professor) in the Department of Mathematics and Statistics at the University of Vaasa, Finland. His research focuses on business and financial mathematics, which integrates mathematics with business and finance. Foad has published various papers, including those on the applications of stochastic models—particularly fractional stochastic models—in financial markets, as well as on stochastic analysis and probability.

Peyman Pirmoradian holds a degree in computer engineering and has a strong interest in international business and data analysis. His research focuses on the intersection of technology and business strategy, exploring how data-driven approaches can enhance decision-making in contract management. This collaboration builds on his interest in applying computational techniques to business and management industries, aiming to bridge analytical methods with real-world strategic challenges.

References

Abi Jaber, E. and Villeneuve, S. (2025) ‘Gaussian agency problems with memory and linear contracts’, *Finance and Stochastics*, 29(1), pp. 143–176. Available at: https://doi.org/10.1007/s00780-024-00548-y

Barton, T.D., Haapio, H., Hazard, J.G. and Passera, S. (2021) ‘Legal innovation in contracting, and beyond: merging design and technology tools for the information age’, in A. Masson and G. Robinson (eds) *Mapping legal innovation: trends and perspectives*. Cham: Springer, pp. 159–187. Available at: https://doi.org/10.1007/978-3-030-47447-8_8

Berger-Walliser, G., Bird, R.C. and Haapio, H. (2011) ‘Promoting business success through contract visualization’, *Journal of Law, Business & Ethics*, 17. Available at: https://ssrn.com/abstract=1744096 (Accessed: 31 January 2025).

Bertsimas, D. and Thiele, A. (2006) ‘Robust and data-driven optimization: modern decision-making under uncertainty’, Massachusetts Institute of Technology (MIT). Available at: https://www.mit.edu/~dbertsim/papers/Robust%20Optimization/Robust%20and%20data-driven%20optimization-%20modern%20decision-making%20under%20uncertainty.pdf (Accessed: 21 January 2025).

Cummins, T. (2015) ‘Strategic contracting as a source of organizational success’, *International Journal of Commerce and Contracting*, 1(1), pp. 7–14. Available at: https://doi.org/10.1177/2055563615579585

Cummins, T. (2025) ‘Understanding barriers to relational contracting: exploring challenges and solutions’, in J.D. Rendtorff, L. Belser and J. Geraldo Schwengber (eds) *Advances in relational economics. Relational economics and organization governance*. Cham: Springer Nature Switzerland, pp. 147–156. Available at: https://doi.org/10.1007/978-3-031-75725-9_7

Davari, M. and Demeulemeester, E. (2019) ‘The proactive and reactive resource-constrained project scheduling problem’, *Journal of Scheduling*, 22(1), pp. 211–237. Available at: https://doi.org/10.1007/s10951-017-0553-x

Fang, F., van der Valk, W., Vos, B. and Akkermans, H.A. (2024) ‘Down the drain: the dynamic interplay of governance adjustments addressing setbacks in large public–private projects’, *Journal of Operations Management*, 70(1), pp. 80–106. Available at: https://doi.org/10.1002/joom.1277

Farhadali, M. (2024) ‘Navigating business law: essential legal principles for compliance, risk management, and strategic decision-making in the modern marketplace’, *Business Studies Journal*, 16(3), pp. 1–3.

Feinman, J.M. (2024) ‘Recapturing relational contract theory’, Rutgers Law School Research Paper. Available at: https://doi.org/10.2139/ssrn.5059274

Frydlinger, D. and Hart, O. (2023) ‘Overcoming contractual incompleteness: the role of guiding principles’, *The Journal of Law, Economics, & Organization*, 40(3), pp. 625–647. Available at: https://doi.org/10.1093/jleo/ewac027

Frydlinger, D., Hart, O. and Vitasek, K. (2019) ‘A new approach to contracts: how to build better long-term strategic partnerships’, *Harvard Business Review*, 97(5), pp. 116+. Available at: https://link.gale.com/apps/doc/A599089506/AONE?u=anon~12916629&sid=googleScholar&xid=a0b9be45 (Accessed: 31 January 2025).

Griffo, C., Araujo, L.C., Meira Brasil Jr. S., Marques, M.L., Guizzardi, G. and Almeida, J.P.A. (2023) ‘Modeling the dynamics of contractual relations’, *Frontiers in Artificial Intelligence*, 6, article 1042319. Available at: https://doi.org/10.3389/frai.2023.1042319

Haapio, H. (2006) ‘Business success and problem prevention through proactive contracting’, in Wahlgren, P. (ed.) *A proactive approach. Scandinavian studies in law*, 49, pp. 149–194. Stockholm: Stockholm Institute for Scandinavian Law. Available at: Available at: https://www.scandinavianlaw.se/pdf/49-9.pdf (Accessed: 31 January 2025).

Haapio, H., deRooy, R. and Barton, T.D. (2018) ‘New contract genres’, in E. Schweighofer *et al.* (eds) *Data protection / LegalTech: Proceedings of the 21st International Legal Informatics Symposium (IRIS 2018).* Bern: Editions Weblaw, pp. 455–460. Also published in *Jusletter IT*, 22 February. *California Western School of Law Research Paper*, (18-8). Available at: https://ssrn.com/abstract=3144236 (Accessed: 31 January 2025).

Hart, O. (2017) 'Incomplete contracts and control', *American Economic Review*, 107(7), pp. 1731–1752. Available at: https://doi.org/10.1257/aer.107.7.1731

Hurmerinta-Haanpää, A. and Berger-Walliser, G. (2024) 'Joint value creation: a functional, proactive approach to contract governance', *American Business Law Journal*, 61(4), pp. 261–283. Available at: https://doi.org/10.1111/ablj.12252

Jarunde, N. (2023) 'Real-time risk monitoring with big data analytics for derivatives portfolios', *International Journal of Science and Research (IJSR)*, 12(9), pp. 2185–2189. Available at: https://doi.org/10.21275/SR24517154713

Jolls, C. (1997) 'Contracts as bilateral commitments: a new perspective on contract modification', *The Journal of Legal Studies*, 26(1), pp. 203–237. Available at: https://doi.org/10.1086/467993

Khoshsirat, M. and Mousavi, S.M. (2024) 'A new proactive and reactive approach for resource-constrained project scheduling problem under activity and resource disruption: a scenario-based robust optimization approach', *Annals of Operations Research*, 338, pp. 597–643. Available at: https://doi.org/10.1007/s10479-024-05895-9

Kostritsky, J.P. (2019) 'A bargaining dynamic transaction cost approach to understanding framework contracts', *American University Law Review*, 68(5), article 4. Available at: https://digitalcommons.wcl.american.edu/aulr/vol68/iss5/4 (Accessed: 31 January 2025).

Li, X., He, Z. and Wang, N. (2023) 'A branch-and-bound algorithm for the proactive resource-constrained project scheduling problem with robustness maximization objective'. Available at: https://doi.org/10.2139/ssrn.4385925

Li, S. (2020) 'Information asymmetry between principal and agent in some performance evaluation models'. PhD thesis. Temple University. Available at: https://scholarshare.temple.edu/bitstream/handle/20.500.12613/3197/TETDEDXLi-temple-0225E-14042.pdf (Accessed: 31 January 2025).

Macneil, I.R. (1978) 'Contracts: adjustment of long-term economic relations under classical, neoclassical, and relational contract law', *Northwestern University Law Review*, 72, pp. 854–905.

Nystén-Haarala, S. (2006) 'Contract law and everyday contracting', in P. Wahlgren (ed) *A proactive approach. Scandinavian studies in law*, 49. Stockholm: Stockholm Institute for Scandinavian Law, pp. 263–268. Available at: https://www.scandinavianlaw.se/pdf/49-15.pdf (Accessed: 15 October 2024).

Nystén-Haarala, S., Lee, N. and Lehto, J. (2010) 'Flexibility in contract terms and contracting processes', *International Journal of Managing Projects in Business*, 3(3), pp. 462–478. Available at: https://doi.org/10.1108/17538371011056084

Pohjonen, S. (2006) 'Proactive law in the field of law', in P. Wahlgren (ed) *A proactive approach. Scandinavian studies in law*, 49. Stockholm: Stockholm Institute for Scandinavian Law, pp. 53–70. Available at: https://www.scandinavianlaw.se/pdf/49-4.pdf (Accessed: 31 January 2025).

Porter, M.E. and Kramer, M.R. (2018) 'Creating shared value: how to reinvent capitalism—and unleash a wave of innovation and growth', in G.G. Lenssen and N.C. Smith (eds) *Managing sustainable business: an executive education case and textbook*. Dordrecht: Springer Netherlands, pp. 323–346. Available at: https://doi.org/10.1007/978-94-024-1144-7_16

Rekola, K. and Haapio, H. (2011) 'Proactive contracting + service design = success!', *International Journal of Services, Economics and Management*, 3(4), pp. 376–392. Available at: https://doi.org/10.1504/IJSEM.2011.042783

Rubin, G.D. and Patel, B.N. (2017) 'Financial forecasting and stochastic modeling: predicting the impact of business decisions', *Radiology*, 283(2), pp. 342–358. Available at: https://doi.org/10.1148/radiol.2017161800

Saloranta, J. and Hurmerinta-Haanpää, A. (2023) 'Proactive contract theory in the context of corporate sustainability due diligence', *Journal of Strategic Contracting and Negotiation*, pp. 1–16. Available at: https://ssrn.com/abstract=4440537 (Accessed: 31 January 2025).

Sharma, S. and Kumar, V. (2022) 'A comprehensive review on multi-objective optimization techniques: past, present and future', *Archives of Computational Methods in Engineering*, 29(7), pp. 5605–5633. Available at: https://doi.org/10.1007/s11831-022-09778-9

Siedel, G.J. and Haapio, H. (2010) 'Using proactive law for competitive advantage', *Ross School of Business Paper*, 1148. Available at: https://doi.org/10.2139/ssrn.1664561

Solarte-Vásquez, M.C. and Nyman-Metcalf, K. (2017) 'Smart contracting: a multidisciplinary and proactive approach for the EU digital single market', *Baltic Journal of European Studies*, 7(2), pp. 208–246. Available at: https://doi.org/10.1515/bjes-2017-0017

Teece, D.J., Pisano, G. and Shuen, A. (1997) 'Dynamic capabilities and strategic management', *Strategic Management Journal*, 18(7), pp. 509–533. Available at: https://doi.org/10.1002/(SICI)1097-0266(199708)18:7<509::AID-SMJ882>3.0.CO;2-Z

Williamson, O.E. (1979) 'Transaction-cost economics: the governance of contractual relations', *Journal of Law and Economics*, 22(2), pp. 233–261. Available at: https://doi.org/10.1086/466942