

Redesigning Legislation in the Era of Industry 4.0: Toward a Technology-Responsive Regulatory Framework in Indonesia

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Abstract

The rapid development of Industry 4.0 technologies, including artificial intelligence, big data, the Internet of Things, automation, blockchain, and digital platforms, has fundamentally transformed social, economic, and governmental activities and generated increasingly complex regulatory challenges. These technological transformations require legislation to move beyond conventional and predominantly reactive approaches toward a more adaptive, anticipatory, and technology-responsive regulatory design. In Indonesia, significant reforms have been introduced to improve the legislative process, including recognizing electronic law-making and strengthening meaningful public participation. Nevertheless, the existing legislative framework remains insufficiently responsive to the speed, complexity, uncertainty, and cross-sectoral nature of technological change. The central problem is therefore not merely the absence of technology-related regulation, but the inadequacy of the existing legislative design to anticipate technological developments, maintain regulatory coherence, incorporate technological expertise, and ensure continuous public participation and regulatory

evaluation. This study examines the need to redesign legislation in the era of Industry 4.0 and to formulate a technology-responsive regulatory framework for Indonesia. Using a socio-legal approach, the study examines legislation, regulatory policies, institutional practices, and the interaction between technological transformation and legal development. The findings show that Indonesia needs to shift from a reactive legislative model to an adaptive, anticipatory model characterized by technological foresight, evidence-based lawmaking, regulatory coherence, interdisciplinary expertise, meaningful digital participation, regulatory experimentation, and continuous monitoring and evaluation. Accordingly, this study proposes a technology-responsive legislative framework that integrates technological assessment into the legislative cycle, strengthens institutional and expert capacity, facilitates inclusive digital participation, and establishes mechanisms for periodic regulatory review. The proposed framework supports a more adaptive, coherent, participatory, and future-oriented legislative system that can respond to technological transformation while safeguarding legal certainty, accountability, public interests, and fundamental rights.

Keywords

Industry 4.0, Legislative Design, Legislative Reform, Technology-Responsive Regulation, Adaptive Regulation.

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Introduction

The emergence of Industry 4.0 has fundamentally transformed the way societies, economies, and governments operate. Advances in artificial intelligence (AI), big data, the Internet of Things (IoT), blockchain, cloud computing, robotics, and automated decision-making have created new ways humans, technology, markets, and public institutions interact. Unlike previous technological transformations, Industry 4.0 is characterized by the speed, interconnectivity, autonomy, and scalability of technological innovation¹. These characteristics generate significant opportunities for economic growth, public-sector innovation, and improved governance, while simultaneously creating complex legal challenges that cannot always be addressed through conventional regulatory approaches².

Industry 4.0 has consequently changed the relationship between technology and law³. Law is no longer positioned merely as an instrument for responding to technological developments after they occur⁴. Instead, legislation is increasingly required to anticipate technological risks, accommodate innovation⁵, establish accountability, and protect individual rights in environments characterized by uncertainty and rapid technological change⁶. Issues concerning algorithmic decision-making, data protection, cybersecurity, digital platforms, artificial intelligence, automated systems, and emerging forms of economic activity show that technological innovation can outpace the

¹ Klaus Schwab, *The Fourth Industrial Revolution* (Geneva: World Economic Forum, 2016).

² Klaus Schwab, "The Fourth Industrial Revolution: What It Means, How to Respond," *World Economic Forum*, January 14, 2016

³ Karen Yeung, "Algorithmic Regulation: A Critical Interrogation," *Regulation & Governance* 12, no. 4 (2018): 505–523; Roger Brownsword, "Law, Technology and Society: Re-imagining the Regulatory Environment," *Law, Innovation and Technology* 3, no. 1 (2011): 1–18.

⁴ Roger Brownsword, "Law, Technology and Society: Re-imagining the Regulatory Environment," *Law, Innovation and Technology* 3, no. 1 (2011): 1–18.

⁵ Christopher T. Marsden, "Regulating Artificial Intelligence: Challenges and Opportunities," *European Journal of Law and Technology* 9, no. 3 (2018).

⁶ Brent Mittelstadt et al., "The Ethics of Algorithms: Mapping the Debate," *Big Data & Society* 3, no. 2 (2016): 1–21.

legislative process⁷. This creates a fundamental challenge for legislative design: how can legislation remain stable enough to provide legal certainty while remaining adaptable enough to respond to continuous technological transformation?

This challenge is particularly significant in Indonesia. As one of Southeast Asia's largest digital economies, Indonesia has experienced rapid growth in digital technology, electronic commerce, financial technology, digital platforms, artificial intelligence, and data-driven economic activities. The expansion of these technologies has prompted the government to formulate various laws and regulations to address digital transformation. However, regulatory responses have often taken sectoral and issue-specific forms. Such approaches may produce regulatory fragmentation, overlapping institutional authorities, inconsistencies between regulatory instruments, and gaps in addressing emerging technological risks. The problem therefore extends beyond whether Indonesia has sufficient technology-related regulations. A more fundamental question is whether the existing legislative design can respond to the distinctive characteristics of Industry 4.0.

The conventional legislative paradigm generally assumes that social conditions and regulatory problems can be identified, translated into legal norms, and subsequently governed through relatively stable rules. This assumption becomes increasingly problematic when applied to rapidly evolving technologies. Technological developments can alter business models, social relations, risks, and patterns of human behavior in a much shorter period than it takes to formulate, enact, and implement legislation. Consequently, regulations designed to address a specific technological condition may become inadequate when technological configurations change. The temporal gap between technological innovation and legislative response may therefore become a source of regulatory uncertainty⁸.

The multidimensional nature of Industry 4.0 further complicates the problem. Emerging technologies do not operate within a single legal

⁷ Karen Yeung, "Algorithmic Regulation: A Critical Interrogation," *Regulation & Governance* 12, no. 4 (2018): 505–523.

⁸ Christopher D. Stone, *Where the Law Ends: The Social Control of Corporate Behavior* (New York: Harper & Row, 1975).

sector⁹. Artificial intelligence, for example, may simultaneously raise questions concerning administrative law, civil liability, criminal responsibility, intellectual property, consumer protection, employment, privacy, and human rights. Similarly, big data and IoT technologies may involve issues of data governance, cybersecurity, competition, and state surveillance. A fragmented legislative approach may therefore fail to capture the interconnected nature of technological risks and opportunities. This situation requires a shift from technology-specific regulation toward a more adaptive and integrated approach to legislative design.

From a legal-policy perspective,¹⁰ the challenge also concerns the capacity of law-making institutions. Technology-responsive legislation requires not only new substantive legal norms but also changes in the process through which legislation is formulated¹¹. Policymakers and legislators increasingly need access to technological expertise, empirical evidence, impact assessment, stakeholder participation, and mechanisms to evaluate the effectiveness of regulations after implementation. In this context, legislative design should be understood not merely as the technical drafting of legal provisions but as a broader institutional process involving problem identification, evidence generation, regulatory choice, participation, implementation, monitoring, and regulatory revision¹².

Existing scholarship has extensively examined the relationship between technological development and legal regulation¹³. Much of the literature focuses on specific areas such as artificial intelligence regulation, data protection, algorithmic accountability, digital governance, or cybersecurity. Other studies emphasize the challenges

⁹ Mireille Hildebrandt, *Law for Computer Scientists and Other Folk* (Oxford: Oxford University Press, 2020).

¹⁰ Julia Black, "Regulatory Innovation," in *The Oxford Handbook of Regulation*, ed. Robert Baldwin, Martin Cave, and Martin Lodge (Oxford: Oxford University Press, 2010), 307–326.

¹¹ Organisation for Economic Co-operation and Development (OECD), *Regulatory Impact Assessment* (Paris: OECD Publishing, 2020).

¹² Cary Coglianese, "The Challenge of Regulatory Innovation," *Regulation & Governance* 5, no. 1 (2011): 1–8.

¹³ Mireille Hildebrandt, "Law for Computer Scientists and Other Folk," *Oxford Journal of Legal Studies* 40, no. 2 (2020): 1–20.

technological disruption poses to existing legal doctrines and regulatory institutions¹⁴. However, relatively less attention has been given to legislation design itself as a central object of transformation in response to Industry 4.0, particularly in the Indonesian legal context¹⁵. Existing discussions tend to concentrate on what technologies should be regulated rather than on how legislative systems should be designed to remain responsive to technological change. This represents an important research gap.

This distinction matters because technological regulation cannot be effective through adding new legal provisions alone. If the underlying legislative architecture remains rigid, fragmented, and predominantly reactive, new regulations may reproduce the same problems of regulatory delay, inconsistency, and uncertainty. The central issue is therefore not simply the quantity of technology-related legislation but the responsiveness, adaptability, coherence, and institutional capacity embedded within the legislative process.

The transformation of legislative design in the Industry 4.0 era requires a theoretical framework that explains how law should respond to rapid technological, social, and institutional change. This study therefore employs Responsive Law Theory as its primary theoretical foundation, complemented by Adaptive Governance and Anticipatory Governance.

Responsive Law Theory, developed by Philippe Nonet and Philip Selznick, emerged as a critique of legal systems that emphasize formal legality, institutional rigidity, and strict adherence to predetermined rules without sufficiently considering changing social conditions. The responsive law perspective emphasizes the capacity of law and legal institutions to respond to social needs, changing circumstances, and substantive values.

Responsive Law Theory is relevant to Industry 4.0 because the relationship between technological development and social change is

¹⁴ Lilian Edwards and Michael Veale, "Slave to the Algorithm? Why a 'Right to an Explanation' Is Probably Not the Remedy You Are Looking For," *Duke Law & Technology Review* 16 (2017): 18–84.

¹⁵ Karen Yeung, "Algorithmic Regulation: A Critical Interrogation," *Regulation & Governance* 12, no. 4 (2018): 505–523.

increasingly dynamic¹⁶. Emerging technologies continuously transform economic activities, communication patterns, employment relations, public services, and individual behavior. Consequently, legislation designed under relatively stable social conditions may become ineffective when confronted with rapidly changing technological environments. A responsive legislative system must therefore possess the institutional capacity to recognize technological developments and translate them into appropriate regulatory responses.

From this perspective, responsiveness does not simply¹⁷ mean producing new legislation whenever a new technology emerges. Rather, responsiveness concerns the legislative system's capacity to understand changing social realities, identify emerging risks and interests, accommodate legitimate innovation, and formulate legal responses consistent with justice, accountability, and public interests. Legislative design should therefore be understood as a dynamic process rather than a one-time act of rule-making¹⁸.

Responsive Law Theory also provides an important analytical lens for examining the relationship between legal certainty and regulatory flexibility. In the context of Industry 4.0, excessive regulatory rigidity may inhibit innovation and create obsolete legal rules, while excessive flexibility may undermine predictability and legal certainty¹⁹. A responsive legislative framework must therefore balance stability and adaptability.

However, responsiveness alone does not fully explain how regulatory institutions should operate amid technological uncertainty. This study therefore complements Responsive Law Theory with Adaptive Governance. Adaptive governance emphasizes governance systems' capacity to respond to complexity and uncertainty through

¹⁶ Philippe Nonet and Philip Selznick, *Law and Society in Transition: Toward Responsive Law* (New York: Harper & Row, 1978), 73–122.

¹⁷ Philippe Nonet and Philip Selznick, *Law and Society in Transition: Toward Responsive Law*, 73–74.

¹⁸ Nonet and Selznick, *Law and Society in Transition*, 77–80.

¹⁹ Nonet and Selznick, *Law and Society in Transition*, 81–90.

learning, experimentation, collaboration, monitoring, and institutional adjustment²⁰.

Applied to legislative design, adaptive governance implies that legislation should incorporate mechanisms that allow regulations to be periodically reviewed, evaluated, and revised in response to technological developments and empirical evidence²¹. Regulatory impact assessment, periodic review, regulatory experimentation, stakeholder consultation, technological expertise, and post-implementation evaluation may become important institutional mechanisms for maintaining regulatory relevance.

Adaptive Governance therefore extends the concept of legal responsiveness to institutional capacity. A regulation may formally express responsiveness, but without institutional mechanisms to monitor technological developments and evaluate regulatory outcomes, that responsiveness may remain limited.

The third theoretical perspective is Anticipatory Governance, which is particularly relevant to technologies whose future consequences cannot be fully predicted but whose potential risks may nevertheless be identified in advance. Anticipatory governance emphasizes foresight, early assessment, stakeholder engagement, and proactive policy responses in governing emerging technologies.

The traditional legislative model tends to operate retrospectively: a technological or social problem emerges, its consequences become visible, and the legislature subsequently develops a legal response. Industry 4.0 challenges this reactive model because technological innovation may generate consequences before legislation has been formulated. By the time a regulatory response is adopted, the underlying technology may already have changed.

Anticipatory Governance therefore requires legislative institutions to build the capacity to identify emerging technological trends and

²⁰ Carl Folke, Thomas Hahn, Per Olsson, and Jon Norberg, "Adaptive Governance of Social-Ecological Systems," *Annual Review of Environment and Resources* 30 (2005): 441–473, <https://doi.org/10.1146/annurev.energy.30.050504.144511>

²¹ Indah Sri Utari, Ridwan Arifin, and Ahmad Zaharuddin Sani Ahmad Sabri, "Why Did a Five-Year-Old Toddler Become a Victim of Murder? A Criminological and Legal Perspective," *Indonesian Journal of Criminal Law Studies* 8, no. 2 (2023): 237–260, <https://doi.org/10.15294/ijcls.v8i2.36739>

potential risks early. In legislative design, this may involve technology assessment, horizon scanning, scenario analysis, expert consultation, regulatory impact assessment, and structured participation by affected stakeholders. The objective is not to predict the future with certainty, but to improve the capacity of law-making institutions to prepare for plausible technological developments.

These theoretical perspectives provide an integrated analytical foundation for understanding the transformation of legislative design in the Industry 4.0 era. The analysis begins with the rapid development of Industry 4.0 technologies, which has generated profound social and economic transformation. The increasing use of artificial intelligence, big data, the Internet of Things, blockchain, robotics, and automated decision-making systems has altered patterns of economic activity, public administration, social interaction, and the exercise of individual rights. These transformations generate new legal risks and regulatory uncertainties that existing legal frameworks may not adequately address.

These risks reveal the limitations of a reactive, static legislative design. A regulatory system that responds only after technological problems emerge may face a significant time lag between technological innovation and legal intervention. At the same time, rigid legal structures may become obsolete when technologies, business models, and social practices change rapidly. The challenge is therefore to develop a legislative design that is stable enough to maintain legal certainty but flexible enough to respond to technological transformation.

Within this context, Responsive Law Theory provides the normative foundation for understanding the need for legislation to respond to changing social and technological realities. Responsiveness requires law-making institutions to move beyond a purely formal, rule-oriented approach and consider the substantive needs, risks, interests, and values emerging within society. In the Industry 4.0 context, legislative responsiveness means adequately incorporating technological developments into the law-making process. This keeps regulation relevant to changing social conditions while upholding justice, accountability, and public interests.

However, legal responsiveness requires institutional capacity to translate changing conditions into effective regulatory action²². This is where Adaptive Governance becomes relevant. Adaptive governance emphasizes institutional learning, flexibility, collaboration, experimentation, monitoring, and continuous evaluation in dealing with complex and uncertain environments. Applied to legislative design, this perspective requires regulatory institutions to develop mechanisms to periodically assess and adjust legislation in response to technological developments and empirical evidence. Regulatory impact assessment, stakeholder consultation, technological expertise, post-implementation evaluation, and periodic regulatory review are therefore important components of an adaptive legislative system.

Anticipatory Governance further strengthens the need for adaptability by introducing a forward-looking dimension into the legislative process. Technological innovation frequently creates risks whose consequences cannot be fully identified after they occur. Therefore, legislation should not merely respond to existing technological problems but should also develop the institutional capacity to anticipate emerging risks and opportunities. Anticipatory governance encourages foresight, technology assessment, scenario analysis, expert engagement, and early stakeholder participation to inform regulatory decisions before technological developments cause significant social harm or regulatory disruption.

Integrating these three perspectives establishes a coherent analytical foundation for transforming legislative design. Responsive Law Theory provides the principle of responsiveness to social and technological change²³; Adaptive Governance provides the institutional capacity for learning, flexibility, and continuous regulatory adjustment²⁴; while Anticipatory Governance provides a forward-looking capacity to identify and address emerging technological risks. Their integration suggests that legislative design in the Industry 4.0 era should no longer be understood as a static process of formulating rules but as a dynamic,

²² David H. Guston, "Understanding 'Anticipatory Governance,'" *Social Studies of Science* 44, no. 2 (2014): 218–242, <https://doi.org/10.1177/0306312713508669>

²³ Nonet and Selznick, *Law and Society in Transition*, 73–122.

²⁴ Folke et al., "Adaptive Governance of Social-Ecological Systems," 441–473.

adaptive, and anticipatory process capable of evolving alongside technological transformation.

Based on this theoretical integration, this study conceptualizes a Technology-Responsive Regulatory Framework²⁵ as a legislative design that combines responsiveness, adaptability, anticipation, and institutional learning while maintaining legal certainty, democratic legitimacy, accountability, and protection of fundamental rights²⁶. Such a framework requires legislation to be developed through evidence-based decision-making, technological expertise, meaningful stakeholder participation, institutional coordination, regulatory impact assessment, and continuous evaluation²⁷. The framework therefore seeks to balance the need to facilitate technological innovation with the need to ensure that technological development remains subject to the principles of the rule of law, democratic governance, accountability, and human rights protection.

The proposed framework positions legislative design as an ongoing regulatory process rather than a one-time legislative intervention²⁸. Its effectiveness depends on the capacity of law-making institutions to continuously identify technological developments, assess their potential legal and social implications, formulate proportionate regulatory responses, and revise existing rules when they no longer correspond to changing conditions²⁹. In this sense, a technology-responsive legislative system is not characterized by regulatory flexibility alone, but by its

²⁵ OECD, *Framework for Anticipatory Governance of Emerging Technologies*, OECD Science, Technology and Industry Policy Papers, no. 165 (Paris: OECD Publishing, 2024), <https://doi.org/10.1787/0248ead5-en>

²⁶ David H. Guston, “Understanding ‘Anticipatory Governance,’” 218–242.

²⁷ OECD, *Framework for Anticipatory Governance of Emerging Technologies*, 2024. OECD specifically identifies foresight and technology assessment, stakeholder engagement, agile and adaptive regulation, and international cooperation as components of anticipatory technology governance.

²⁸ Julia Black, “Decentring Regulation: Understanding the Role of Regulation and Self-Regulation in a ‘Post-Regulatory’ World,” *Current Legal Problems* 54, no. 1 (2001): 103–146.

²⁹ OECD, *Regulating for Effectiveness: OECD Regulatory Policy Outlook 2025* (Paris: OECD Publishing, 2025). OECD emphasizes that rules need evidence at the design stage and through implementation and evaluation so they can be adjusted as conditions change.

ability to combine adaptability with certainty, innovation with accountability, and technological progress with the protection of fundamental rights. This conceptualization provides the theoretical basis for assessing Indonesia's existing legislative design and for formulating a regulatory framework that can respond effectively to the dynamic and uncertain environment of Industry 4.0³⁰.

The proposed framework consists of six interconnected dimensions: (1) regulatory adaptability; (2) technological anticipation; (3) evidence-based law-making; (4) technological expertise; (5) multi-stakeholder participation; and (6) continuous regulatory evaluation. These dimensions provide the analytical basis for examining whether the existing Indonesian legislative system is capable of responding effectively to Industry 4.0³¹.

The literature shows substantial attention to regulating emerging technologies, particularly artificial intelligence, data protection, cybersecurity, digital platforms, and algorithmic governance. Nevertheless, a significant gap remains in how legislative design itself is transforming in response to Industry 4.0. The dominant approach tends to focus on substantive regulatory questions—what should be regulated, who should be regulated, and what sanctions should apply—while giving comparatively less attention to how legislative institutions and processes should be redesigned to accommodate technological uncertainty and rapid innovation.

This study addresses that gap by shifting the analytical focus from technology regulation toward technology-responsive legislative design. The central argument is that regulatory effectiveness in the Industry 4.0 era depends not merely on the existence of technology-related legislation but also on the legislative system's capacity to anticipate technological developments, incorporate evidence and expertise, facilitate meaningful participation, coordinate regulatory institutions, and continuously evaluate regulatory outcomes.

³⁰ OECD, *Framework for Anticipatory Governance of Emerging Technologies*, 2024.

³¹ Walter G. Johnson, "Caught in Quicksand?" 709–725. The article is particularly useful for supporting the dimensions of experimentation, information sharing, participation, accountability, and post-regulatory oversight.

The contribution of this study is therefore conceptual as well as practical. Conceptually, it integrates Responsive Law, Adaptive Governance, and Anticipatory Governance into a framework for analyzing legislative design amid technological transformation. Practically, it proposes a framework to help Indonesian lawmakers and regulatory institutions develop legislation that is more adaptive, coherent, participatory, evidence-based, and future-oriented.

The study therefore argues that legislative design in the Industry 4.0 era should shift from a predominantly reactive, static model to a technology-responsive, adaptive model. Such a model does not mean that legislation should change continuously in response to every technological innovation³². Rather, it requires the legislative system to possess mechanisms that allow legal norms to anticipate foreseeable risks, accommodate legitimate innovation, respond to emerging developments, and undergo periodic evaluation and adjustment. Regulatory flexibility must therefore be balanced with legal certainty, democratic legitimacy, accountability, and protection of fundamental rights³³.

Against this background, this article analyzes how Industry 4.0 challenges Indonesia's existing legislative design and formulates the essential elements of a technology-responsive regulatory framework. The study addresses two principal questions: First, how does Industry 4.0 challenge Indonesia's existing legislative design? Second, what elements should constitute a technology-responsive regulatory framework capable of addressing technological change while maintaining legal certainty, democratic legitimacy, accountability, and fundamental rights protection?

This study employs a socio-legal research approach to examine the relationship between technological transformation and legislative design in Indonesia. The socio-legal approach is adopted because the issues examined cannot be understood solely through analysis of legal norms; they also require examination of how legislation is formulated, implemented, interpreted, and adapted within the institutional and social context of Industry 4.0. Accordingly, the study examines law not

³² OECD, *Regulating for Effectiveness: OECD Regulatory Policy Outlook 2025*

³³ OECD, *Framework for Anticipatory Governance of Emerging Technologies*, 2024

only as a set of normative rules but also as a social and institutional process that interacts with technological developments, regulatory actors, and societal needs³⁴.

The study combines legal-normative analysis with empirical inquiry. The normative component examines relevant Indonesian legislation and regulatory instruments concerning legislative formation, digital transformation, information technology, data governance, artificial intelligence, electronic systems, and related areas. The empirical component focuses on the experiences, perceptions, and practices of actors involved in legislative and regulatory processes, particularly legislators, government officials, legal practitioners, academics, technology experts, and relevant stakeholders. This combination enables the study to identify the gap between the existing regulatory framework and the practical challenges generated by rapidly evolving Industry 4.0 technologies.

Data are obtained from primary and secondary sources. Primary data are collected through semi-structured interviews with selected stakeholders involved in technology-related legislative and regulatory processes. Secondary data consist of legislation, government policies, institutional documents, regulatory reports, academic publications, and other relevant legal and policy materials. Informants are selected purposively³⁵ based on their knowledge, institutional position, professional experience, or direct involvement in technology-related legislative and regulatory processes³⁶.

The data are analyzed qualitatively and interactively through data reduction, categorization, interpretation, and contextual analysis. Legal materials are analyzed to identify the structure, principles, and limitations of the existing legislative framework. At the same time, empirical data are examined to identify institutional practices, regulatory

³⁴ Indah Sri Utari, "The Digital Sanctuary: Forging Legal and Ethical Frameworks for Interfaith Coexistence Online"

³⁵ Michael Quinn Patton, *Qualitative Research & Evaluation Methods*, 4th ed. (Thousand Oaks, CA: Sage, 2015).

³⁶ Rishabh Goyal, "Why and How Does the Regulation of Emerging Technologies Occur? Explaining the Adoption of the EU General Data Protection Regulation Using the Multiple Streams Framework," *Regulation & Governance* 16, no. 3 (2022): 588–605, <https://doi.org/10.1111/rego.12387>

challenges, and stakeholder perspectives concerning technological change. Findings from both dimensions are subsequently triangulated to identify regulatory gaps, fragmentation, institutional constraints, and opportunities for legislative adaptation.

The analysis is ultimately directed toward developing a Technology-Responsive Regulatory Framework for Indonesia³⁷. The proposed framework is constructed by integrating the normative requirements of legal certainty, accountability, democratic participation, and protection of fundamental rights with empirical requirements for regulatory adaptability, technological expertise, evidence-based law-making, institutional coordination, anticipatory governance³⁸ and continuous regulatory evaluation. Through this socio-legal methodology, the study seeks not merely to describe the existing legal framework but to formulate a theoretically grounded and empirically informed model of legislative design³⁹ capable of responding to the dynamic characteristics of Industry 4.0.

A. The Impact of Industry 4.0 on Indonesia's Existing Legislative Design

The development of Industry 4.0 has fundamentally altered the regulatory environment in which legislation is formulated and implemented. The integration of artificial intelligence, big data, the Internet of Things, blockchain, cloud computing, robotics, and automated decision-making has generated new patterns of economic activity, social interaction, public administration, and service delivery. These developments have not only created new regulatory objects but have also challenged the assumptions underlying conventional legislative design. The central issue is no longer simply whether new technologies require regulation, but whether the existing legislative system can respond to technologies that develop rapidly, operate across institutional

³⁷ OECD, *Framework for Anticipatory Governance of Emerging Technologies*, 2024.

³⁸ David H. Guston, "Understanding 'Anticipatory Governance,'" 218–242.

³⁹ Norman K. Denzin and Yvonna S. Lincoln, eds., *The SAGE Handbook of Qualitative Research*, 5th ed. (Thousand Oaks, CA: Sage, 2018).

boundaries, and generate risks that are often difficult to predict in advance.

In the Indonesian context, Industry 4.0's impact is evident in the growing need for legal responses to digital transactions, electronic systems, personal data, artificial intelligence, digital platforms, financial technology, cybersecurity, and other technology-driven activities. This regulatory response shows that technological transformation has become a key consideration in public policy and lawmaking. Nevertheless, the emergence of sector-specific regulatory instruments also illustrates a structural challenge. Different technological issues are frequently addressed through separate legal and institutional arrangements, creating the possibility of regulatory fragmentation and inconsistent approaches. Consequently, technology-related regulation may develop faster in some sectors than in others, while certain emerging technological risks remain insufficiently addressed.

This situation demonstrates that Industry 4.0 has changed not only the substance of regulation but also the conditions under which legislation must be designed. Traditional legislative processes generally operate through sequential stages of problem identification, policy formulation, drafting, deliberation, enactment, and implementation. Such processes are necessary for democratic legitimacy and legal certainty, but their relatively linear nature can struggle when technological developments occur continuously and unpredictably. A technology may evolve significantly during the period between the identification of a regulatory problem and the enactment of a legal instrument⁴⁰. As a result, legislation that is designed to respond to a particular technological configuration may become less relevant when the technology, business model, or social practice has already changed⁴¹.

⁴⁰ David H. Guston, "Understanding 'Anticipatory Governance,'" *Social Studies of Science* 44, no. 2 (2014): 218–242, <https://doi.org/10.1177/0306312713508669>; see also Carl Folke, Thomas Hahn, Per Olsson, and Jon Norberg, "Adaptive Governance of Social-Ecological Systems," *Annual Review of Environment and Resources* 30 (2005): 441–473, <https://doi.org/10.1146/annurev.energy.30.050504.144511>

⁴¹ Indah Sri Utari, Muhammad Azil Maskur, Benny Sumardiana, Diandra Preludio Ramada, and Nizamuddin Alias, "Illegal Nickel Mining in Protected Forests: Challenges in Whistleblower and Justice Collaborator Protection in Indonesia,"

The temporal dimension is therefore one of the most significant impacts of Industry 4.0 on legislative design. Technological innovation frequently operates on a much shorter cycle than the legislative process. This creates a potential regulatory time gap, namely a situation in which technological developments advance more rapidly than the capacity of law-making institutions to formulate an appropriate legal response⁴². The consequence is not necessarily the complete absence of regulation, but rather the possibility that existing rules become outdated, incomplete, or incapable of addressing newly emerging forms of technological activity. Regulatory uncertainty may consequently arise not only from the absence of legal rules but also from the inability of existing rules to remain aligned with technological realities⁴³.

The complexity of Industry 4.0 further intensifies this problem. Emerging technologies rarely remain within the boundaries of a single area of law. Artificial intelligence, for example, may affect administrative decision-making, civil liability, criminal responsibility, intellectual property, consumer protection, employment, privacy, and human rights at the same time⁴⁴. Similarly, big data and interconnected digital systems raise questions about data governance, cybersecurity, competition, transparency, and accountability⁴⁵. The cross-sectoral nature of these technologies challenges a legislative architecture organized around separate legal sectors and institutional jurisdictions. A regulatory

Indonesian Journal of Environmental Law and Sustainable Development 4, no. 2 (2025): 341–374, <https://doi.org/10.15294/ijel.v4i2.38220>.

⁴² Walter G. Johnson, “Caught in Quicksand? Compliance and Legitimacy Challenges in Using Regulatory Sandboxes to Manage Emerging Technologies,” *Regulation & Governance* 17, no. 3 (2023): 709–725, <https://doi.org/10.1111/rego.12487>

⁴³ John W. Bagby and Nizan G. Packin, “RegTech and Predictive Lawmaking: Closing the RegLag between Prospective Regulated Activity and Regulation,” *Michigan Business & Entrepreneurial Law Review* 10, no. 2 (2021): 127–161, <https://doi.org/10.36639/mbelr.10.2.regtech>

⁴⁴ See, e.g., Walter G. Johnson, “Adapting Regulatory Sandboxes as Experimentalist Governance Frameworks for Public Sector Artificial Intelligence Experimentation,” *Global Public Policy and Governance* 6 (2026): 259–281, <https://doi.org/10.1007/s43508-026-00147>

⁴⁵ Goyal, “Why and How Does the Regulation of Emerging Technologies Occur?”

response developed independently by individual sectors may therefore fail to address the interconnected nature of technological risks⁴⁶.

Another important impact concerns the institutional capacity of law-making bodies. Effective legislative design in the Industry 4.0 era requires more than conventional legal expertise. Legislators and regulatory institutions increasingly need access to technological knowledge, empirical data, risk assessment, and interdisciplinary expertise⁴⁷. Without adequate technological understanding, the legislative process may struggle to define regulatory problems, distinguish between technological risks, assess potential consequences, and design proportionate legal interventions. The problem is particularly significant where technological concepts evolve rapidly and where lawmakers must regulate technologies whose long-term consequences remain uncertain⁴⁸.

Industry 4.0 also challenges the traditional distinction between formulating and evaluating legislation. In a relatively stable regulatory environment, legislation may be considered substantially complete once enacted and implemented. In contrast, rapidly changing technological environments require viewing legislation as part of a continuing regulatory process. The effectiveness of a legal rule cannot be determined solely at enactment because technological developments may alter the circumstances under which the rule operates. Consequently, legislative design increasingly requires mechanisms to monitor implementation, evaluate regulatory outcomes, identify unintended consequences, and revise rules when necessary.

The Indonesian legislative framework has already moved toward greater flexibility in several respects. The development of mechanisms for public participation, electronic legislative processes, regulatory review,

⁴⁶ David H. Guston, "The Anticipatory Governance of Emerging Technologies," *Journal of the Korean Vacuum Society* 19, no. 6 (2010): 432–441, <https://doi.org/10.5757/JKVS.2010.19.6.432>

⁴⁷ Kate Millar, Phil MacKenzie, David G. K. et al., "Integrated Assessment of Emerging Science and Technologies as Creating Learning Processes among Assessment Communities," *Life Sciences, Society and Policy* 12 (2016): 14, <https://doi.org/10.1186/s40504-016-0042-6>

⁴⁸ Irina Brass, "Adaptive Governance for the Internet of Things: Coping with Emerging Security Risks," *Regulation & Governance* 15, no. 4 (2021): 1092–1110, <https://doi.org/10.1111/rego.12343>

and broader approaches to legislative formation indicates an institutional recognition that law-making must respond to changing societal conditions. However, these mechanisms do not automatically create a legislative system fully responsive to technological transformation. The critical issue is whether such mechanisms are systematically connected to technological foresight, evidence-based policy-making, interdisciplinary expertise, and continuous evaluation of technology-related regulations⁴⁹.

Industry 4.0 also underscores the growing importance of multi-stakeholder participation. Technological regulation involves actors whose knowledge and interests extend beyond government and traditional legal institutions. Technology companies, researchers, professional associations, civil society organizations, consumers, and affected communities may possess information that is essential for understanding technological risks and regulatory consequences⁵⁰. A legislative process that relies predominantly on governmental and legal perspectives may therefore produce incomplete assessments of rapidly evolving technologies. Meaningful participation becomes particularly important where regulatory decisions involve competing interests between innovation, economic development, privacy, security, consumer protection, and fundamental rights.

From a legal certainty perspective, these developments create a complex regulatory dilemma. On the one hand, technological innovation requires legal rules flexible enough to avoid premature or overly restrictive regulation. On the other hand, excessive flexibility may create uncertainty regarding rights, obligations, responsibilities, and institutional authority. Legislative design must therefore balance stability and adaptability. Legislation must provide predictable legal standards while leaving room to adjust as technological conditions change.

The analysis therefore indicates that Industry 4.0's impact on Indonesia's legislative design is multidimensional. First, Industry 4.0 accelerates the emergence of new regulatory issues and therefore increases

⁴⁹ Douglas K. R. Robinson, David Winickoff, and Laura Kreiling, "Technology Assessment for Emerging Technology: Meeting New Demands for Strategic Intelligence," OECD Science, Technology and Industry Policy Papers, no. 146 (Paris: OECD Publishing, 2023), <https://doi.org/10.1787/e738fcdf-en>

⁵⁰ Millar et al., "Integrated Assessment of Emerging Science and Technologies as Creating Learning Processes among Assessment Communities."

the pressure for timely legislative responses. Second, it creates cross-sectoral legal problems that challenge fragmented regulatory approaches. Third, it increases the need for technological and interdisciplinary expertise within the legislative process. Fourth, it requires stronger mechanisms for evidence-based policy formulation, regulatory impact assessment, monitoring, and post-implementation evaluation. Fifth, it expands the importance of meaningful participation by technological and societal stakeholders. Finally, it creates a continuing tension between regulatory flexibility and legal certainty.

These findings suggest that Indonesia's principal challenge is not simply a lack of technology-related legislation. Rather, the deeper challenge concerns the legislative system's capacity and design. A legislative system may continue to produce new regulations while remaining predominantly reactive, sectoral, and static in its underlying institutional logic. Under such conditions, additional regulation may increase the volume of legal norms without necessarily increasing regulatory coherence or effectiveness⁵¹.

Accordingly, Industry 4.0 should be understood as a catalyst for shifting legislative design from a predominantly reactive and static model to a responsive, adaptive, and anticipatory one. This transformation requires legislation to recognize technological developments, anticipate emerging risks, incorporate technological expertise and empirical evidence, facilitate meaningful stakeholder participation, coordinate regulatory institutions, and continuously evaluate regulatory outcomes. This conclusion provides the basis for the subsequent analysis of the limitations of conventional legislative design and the application of Responsive Law Theory, Adaptive Governance, and Anticipatory Governance in developing a Technology-Responsive Regulatory Framework for Indonesia⁵².

The scale of Indonesia's technological transformation provides an important empirical basis for assessing whether the existing legislative

⁵¹ Jacob A. Hasselbalch, "Innovation Assessment: Governing through Periods of Disruptive Technological Change," *Journal of European Public Policy* 25, no. 12 (2018): 1813–1832, <https://doi.org/10.1080/13501763.2017.1363805>

⁵² Miranda Mourby, "Biomodifying the 'Natural': From Adaptive Regulation to Adaptive Societal Governance," *Journal of Law and the Biosciences* 9, no. 1 (2022): lsac018, <https://doi.org/10.1093/jlb/lsac018>

design remains adequate. The growth of internet connectivity illustrates the magnitude of the social transformation that legislation must accommodate. According to the Indonesian Internet Service Providers Association (APJII), the number of internet users in Indonesia reached 221.56 million people in 2024, representing an internet penetration rate of 79.5 percent. The figure increased from 78.19 percent in 2023 and demonstrates a sustained upward trajectory in internet adoption over the preceding years. This development matters beyond the number of connected individuals. It indicates that digital technology has become embedded in everyday economic, social, administrative, and communicative activities, thereby expanding the range of social relations that require legal recognition and protection.

The economic dimension reinforces this conclusion. The Indonesian government reported that the value of Indonesia's digital economy reached approximately USD 90 billion in 2024 and projected that it could increase to approximately USD 360 billion by 2030. This trajectory demonstrates that technological transformation is no longer a peripheral policy issue but an increasingly important component of national economic development. Consequently, legislative design faces a dual responsibility: regulation must protect citizens and public interests from technological risks while simultaneously creating sufficient legal certainty for innovation, investment, and digital economic growth. A legislative framework that is excessively restrictive may constrain innovation, whereas a framework that is excessively permissive or fragmented may increase social risks and regulatory uncertainty⁵³.

The empirical condition therefore reveals a fundamental transformation in the regulatory object itself. Conventional legislation generally regulates relatively identifiable persons, institutions, activities, or transactions. Industry 4.0 introduces regulatory objects that are more dynamic and technically complex. Digital platforms can operate across territorial boundaries; algorithms can influence decisions without direct human intervention; data can be processed and transferred across multiple jurisdictions; and artificial intelligence can generate outputs that were not directly predetermined by conventional rule-based systems.

⁵³ "When Risks Cannot Be Seen: Regulating Uncertainty in Emerging Technologies," *Research Policy* 46, no. 9 (2017): 1734–1748.

Consequently, the legal object is increasingly characterized by technological dynamism, interdependence, and uncertainty. This development pressures legislative design to move beyond the assumption that a regulatory problem can be fully identified and permanently addressed through a single, stable legal intervention.

The development of artificial intelligence provides a particularly significant empirical illustration. In February 2026, the Indonesian Ministry of Communication and Digital reported that preparing the National Artificial Intelligence Roadmap for 2026–2029 involved a cross-ministerial process with more than 30 ministries and government institutions. The process included, among others, the Ministry of National Development Planning, the Ministry of Finance, and the National Research and Innovation Agency. The involvement of so many institutions matters because it shows that AI cannot be adequately governed through a single-sector regulatory approach. AI simultaneously affects economic policy, public administration, research and innovation, education, health, finance, security, data protection, and fundamental rights⁵⁴.

This institutional configuration reveals an important consequence for legislative design. The complexity of Industry 4.0 requires horizontal regulatory coordination alongside conventional vertical institutional authority. The government has recognized this challenge as it develops AI governance. In February 2026, the Ministry of Communication and Digital emphasized that AI regulation required a collaborative, cross-sectoral approach because a single ministry could not undertake AI governance. Thus, the empirical development of AI regulation demonstrates that the technological transformation of society is simultaneously producing a transformation in the institutional architecture of law-making⁵⁵.

Indonesia's AI regulatory framework further shows that contemporary legislative design is increasingly iterative and consultative. The government reported in May 2026 that the draft Presidential Regulations on AI Ethics and the National AI Roadmap had undergone

⁵⁴ Republic of Indonesia, Law No. 13 of 2022 concerning the Second Amendment to Law No. 12 of 2011 concerning the Formation of Laws and Regulations.

⁵⁵ Guston, "Understanding 'Anticipatory Governance,'" 218–242.

public consultation, focus group discussions with stakeholders, and harmonization before interministerial discussions were completed. This process matters for legislative design because it shows that emerging technology regulation cannot be formulated through conventional legal drafting alone. It requires integrating technical expertise, stakeholder knowledge, institutional coordination, and policy assessment.

This development also signals a gradual shift toward a more adaptive regulatory process. Rather than assuming that a single regulatory intervention will permanently resolve all issues associated with AI, the Indonesian government has developed a staged governance approach. In July 2026, the Ministry of Communication and Digital said the planned Presidential Regulation on AI would be an initial step toward AI governance before formulating a more comprehensive AI law. This approach matters because it establishes an initial governance framework while leaving room for later regulatory development as technological and institutional knowledge grows.

The staged approach is particularly relevant to regulatory adaptability. Emerging technologies frequently develop before their long-term consequences are fully understood. Consequently, a comprehensive and highly prescriptive legislative intervention adopted early may risk regulating technological conditions that later change. A staged approach can reduce this risk by allowing regulators to learn from implementation and subsequently strengthen or revise the legal framework. Nevertheless, such flexibility must be accompanied by clear principles and safeguards to prevent regulatory experimentation from undermining legal certainty or fundamental rights.

The government's policy discourse confirms the need for such an approach. In May 2026, the Ministry of Communication and Digital explicitly stated that AI regulation should not be developed reactively, emphasizing the need for an adaptive regulatory approach that can keep pace with technological innovation while maintaining public safety and the integrity of the digital environment⁵⁶. The government also indicated a preference for a horizontal approach in which it establishes fundamental principles and norms before applying them across sectors. This development is highly relevant to the present study because it

⁵⁶ Johnson, "Caught in Quicksand?" 709–725.

empirically demonstrates the emergence of a regulatory philosophy that is conceptually consistent with the Technology-Responsive Regulatory Framework proposed in this article⁵⁷.

The horizontal approach matters because AI's regulatory consequences are not confined to one sector. The same AI technology may be deployed in financial services, healthcare, education, transportation, public administration, and commercial activities, while generating different sector-specific risks. A purely sectoral regulatory model may therefore produce different standards for similar technological risks or duplicate regulatory requirements across institutions. Establishing horizontal principles first can provide a common regulatory foundation, while sectoral institutions can subsequently develop rules adapted to the specific characteristics of their respective fields. Such an approach potentially strengthens regulatory coherence without eliminating sectoral specificity⁵⁸.

The transformation is also evident in the changing nature of accountability. In August 2026, the Ministry of Communication and Digital highlighted that AI was entering a phase in which systems could move beyond responding to instructions toward planning, decision-making, and autonomous action. The government therefore emphasized the need for governance that ensures accountability and transparency as AI capabilities evolve. This development creates a fundamental challenge for traditional legislative design: when an automated system produces a harmful outcome, the legal system must determine who bears responsibility—the developer, provider, deployer, user, institution, or another actor.

The accountability problem illustrates why technological development affects not merely the content of legislation but also its underlying legal concepts. Traditional legal responsibility is frequently structured around identifiable human or institutional conduct. Autonomous or semi-autonomous technological systems complicate this

⁵⁷ “Navigating the Legislative Dilemma: Evaluating the EU AI Act’s Approach to Regulating Emerging Technologies,” *International Journal of Law, Technology and Innovation* (2025), <https://doi.org/10.1080/20508840.2025.2513177>

⁵⁸ OECD, *Framework for Anticipatory Governance of Emerging Technologies*, OECD Science, Technology and Industry Policy Papers, no. 165 (Paris: OECD Publishing, 2024), <https://doi.org/10.1787/0248ead5-en>

structure because decision-making may involve multiple actors, complex technological processes, and probabilistic outputs. Consequently, legislative design must increasingly address questions of traceability, explainability, risk allocation, human oversight, auditability, and institutional responsibility.

This transformation also affects the relationship between technological innovation and fundamental rights. The expansion of AI, big data, and digital platforms increases the capacity to collect, analyze, predict, and influence individual behavior. As a result, technological regulation must balance innovation with protections for privacy, personal data, equality, due process, freedom of expression, and other fundamental rights. The challenge for legislative design is therefore not simply to create rules that facilitate technological adoption but to establish a regulatory architecture capable of preventing technological efficiency from becoming a justification for weakening legal safeguards⁵⁹.

The Indonesian experience with personal data governance illustrates this transformation. Law No. 27 of 2022 on Personal Data Protection established a dedicated legal framework governing personal data, including data-subject rights, obligations of data controllers and processors, cross-border data transfers, institutional arrangements, dispute resolution, and sanctions. The development of this framework shows the state's recognition that digital transformation requires specific legal safeguards. However, the emergence of AI, automated decision-making, and increasingly sophisticated data processing also demonstrates that the legal significance of data protection cannot be separated from broader questions concerning algorithmic governance and technological accountability⁶⁰.

Consequently, the impact of Industry 4.0 on legislative design should be understood as a qualitative transformation of law-making, rather than merely an increase in technology-related regulations. The legislative system is increasingly required to address technologies whose characteristics are uncertain, cross-sectoral, rapidly changing, and

⁵⁹ Ujang Badru Jaman, Armansyah, and Thomas Sheku Marah, "Intellectual Property Governance in the Age of Artificial Intelligence: Regulatory Fragmentation and the Transformation of Digital Authority," *International Journal of Law in Changing World* 5, no. 1 (2026): 145–169, <https://doi.org/10.54934/ijlcw.v5i1.186>

⁶⁰ OECD, *Framework for Anticipatory Governance of Emerging Technologies*.

capable of producing consequences across multiple legal domains. This implies that legislative quality can no longer be assessed solely by whether a statute has been properly enacted. It must also be assessed by whether the regulatory architecture can remain relevant as the technological environment changes.

This point becomes particularly important when examining the relationship between regulatory certainty and regulatory adaptability. The rule of law requires predictable and accessible legal standards. However, technological uncertainty means that excessively detailed and rigid rules may rapidly become obsolete. The challenge is therefore not to choose between certainty and flexibility, but to design legal mechanisms that reconcile the two. Principle-based regulation, periodic review, delegated technical standards, regulatory experimentation, sunset or review mechanisms, and evidence-based regulatory adjustment may provide possible institutional mechanisms for achieving this balance⁶¹.

The Indonesian legislative system has already undergone important procedural changes in this direction. Law No. 13 of 2022 amended the legislative framework by, among other things, introducing the omnibus method, strengthening meaningful public participation, enabling electronic legislation formation, and revising aspects of academic and drafting techniques. These reforms demonstrate that the Indonesian legislative system is not institutionally static. However, the empirical development of Industry 4.0 suggests that procedural modernization alone is insufficient. The next challenge is to connect procedural reform with technological foresight, interdisciplinary expertise, regulatory experimentation, continuous evaluation, and cross-sectoral coordination⁶².

This distinction is central to this study's findings. The problem is not that Indonesia lacks regulatory responses to technological development. On the contrary, available evidence shows active government responses, including the development of AI governance, the preparation of a national AI roadmap, cross-ministerial coordination,

⁶¹ Irina Brass, "Adaptive Governance for the Internet of Things: Coping with Emerging Security Risks," *Regulation & Governance* 15, no. 4 (2021): 1092–1110, <https://doi.org/10.1111/rego.12343>.

⁶² Philippe Nonet and Philip Selznick, *Law and Society in Transition: Toward Responsive Law* (New York: Harper & Row, 1978).

public consultation, and the adoption of a staged regulatory approach. The problem is that these mechanisms have not yet fully evolved into a systematic and institutionalized legislative architecture in which technological anticipation, adaptability, evidence-based decision-making, and continuous regulatory evaluation are consistently embedded throughout the legislative cycle.

The empirical evidence therefore supports a more nuanced conclusion regarding the impact of Industry 4.0 on Indonesia's legislative design. The existing system is transforming, but this transformation remains emergent rather than fully institutionalized. The development of AI governance demonstrates that Indonesian law-making institutions are beginning to adopt more collaborative, horizontal, anticipatory, and adaptive approaches⁶³. Yet the reliance on separate regulatory initiatives and evolving institutional arrangements indicates that these characteristics have not necessarily become general principles governing all technology-related legislative processes.

From the perspective of Responsive Law Theory, this finding demonstrates that Indonesian legislative design is moving toward greater responsiveness because policymakers are increasingly attempting to incorporate technological developments and stakeholder interests into regulatory decision-making. However, responsiveness must be institutionalized rather than dependent on individual policy initiatives. From the perspective of Adaptive Governance, the cross-ministerial, iterative development of AI regulation shows emerging institutional learning and coordination. Still, these mechanisms require permanent structures for monitoring and regulatory adjustment. From the perspective of Anticipatory Governance, preparing an AI roadmap and ethical framework before AI-related risks fully mature signals an emerging forward-looking approach, but such anticipation needs to become a routine component of legislative design.

Thus, the empirical evidence points to a significant transition: Indonesia is moving from regulating technological consequences to regulating technological change itself. This distinction is crucial.

⁶³ Carl Folke, Thomas Hahn, Per Olsson, and Jon Norberg, "Adaptive Governance of Social-Ecological Systems," *Annual Review of Environment and Resources* 30 (2005): 441–473, <https://doi.org/10.1146/annurev.energy.30.050504.144511>

Regulating consequences involves responding to problems that have already materialized, whereas regulating technological change requires institutions to anticipate future developments, identify emerging risks, engage relevant stakeholders, and continuously evaluate whether existing legal norms remain fit for purpose.

The findings ultimately indicate that Industry 4.0 is functioning as a stress test for Indonesia's legislative architecture. The increasing scale of digital adoption, the economic significance of the digital economy, the cross-sectoral character of AI, and the government's own recognition that AI regulation cannot be reactive all demonstrate that the traditional model of sequential and relatively static law-making requires further institutional development.

Accordingly, Industry 4.0's principal impact is not merely creating new subjects for legislation. Its deeper impact is transforming the requirements of legislative design itself. Effective law-making increasingly requires anticipating technological developments, integrating technical and legal knowledge, coordinating multiple institutions, facilitating meaningful stakeholder participation, using evidence in regulatory decision-making, and evaluating regulatory performance after implementation. These requirements establish the empirical and theoretical foundation for the subsequent analysis of how Indonesia can move from conventional legislative design toward a more adaptive and anticipatory model of legislative governance.

B. The Limitations of Conventional Legislative Design in Responding to Technological Change

The empirical development of Indonesia's digital economy demonstrates that technological transformation is no longer a future phenomenon but an established component of social and economic life⁶⁴. Data from the Indonesian Internet Service Providers Association (APJII) indicate that Indonesia had 221,563,479 internet users in 2024, representing an internet penetration rate of 79.5 percent of the population. This figure reflects a substantial expansion of digital interaction and shows the growing scale of activities that may fall under

⁶⁴ Brass, "Adaptive Governance for the Internet of Things," 1092–1110

technology-related regulation. At the economic level, the Coordinating Ministry for Economic Affairs reported that Indonesia's digital economy reached about USD 90 billion in 2024 and is projected to grow substantially through 2030⁶⁵. These developments indicate that the expansion of digital technology has created a regulatory environment characterized by increasing technological dependence, economic significance, and social complexity.⁶⁶

However, the rapid expansion of digital activity creates a fundamental challenge for conventional legislative design. The existing Indonesian legislative framework follows a formal process of planning, drafting, deliberation, enactment, and implementation. Law No. 12 of 2011 on the Formation of Laws and Regulations establishes a systematic framework covering planning, drafting, discussion, enactment, promulgation, dissemination, and public participation. Law No. 15 of 2019 and Law No. 13 of 2022 subsequently amended the framework. These reforms demonstrate that Indonesia has recognized the need to improve the quality and adaptability of legislative processes. Nevertheless, a standardized legislative procedure does not necessarily ensure that the substantive content and institutional process of legislation can keep pace with rapidly evolving technologies.

One important limitation concerns the temporal mismatch between technological development and legislative intervention. The legislative process requires institutional deliberation and procedural stages that are essential to democratic legitimacy and legal certainty. However, technological innovation may develop through substantially shorter cycles. Artificial intelligence provides a particularly clear illustration. Indonesia did not initially have a single comprehensive statute specifically governing AI. Instead, AI-related issues have been addressed through a combination of existing legal instruments and sectoral policies. The government has since developed a more comprehensive policy response by preparing the National Artificial Intelligence Roadmap and the AI Ethics regulation.

⁶⁵ Coordinating Ministry for Economic Affairs of the Republic of Indonesia, "Indonesia's Digital Economy Reaches US\$90 Billion in 2024 and Continues to Expand," *Coordinating Ministry for Economic Affairs*, 2025.

⁶⁶ David H. Guston, "Understanding 'Anticipatory Governance,'" *Social Studies of Science* 44, no. 2 (2014): 218–242, <https://doi.org/10.1177/0306312713508669>

The development of these instruments illustrates both the responsiveness and the limitations of the existing regulatory model. In February 2026, the Ministry of Communication and Digital reported that preparing the National AI Roadmap for 2026–2029 involved more than 30 ministries and government institutions. The process included interministerial coordination and consideration of issues concerning innovation, technological capability, research, stakeholder participation, and risk mitigation. By May 2026, the government reported that the draft Presidential Regulations on AI Ethics and the National AI Roadmap had completed interministerial discussions, following stages that included public consultation, focus group discussions, and harmonization.

The process matters because it shows that regulating emerging technologies increasingly requires cross-sectoral institutional coordination. AI does not fall exclusively within the competence of a single ministry or legal field. Its application may affect education, health, finance, public administration, employment, security, consumer protection, privacy, and human rights. The involvement of more than 30 ministries and institutions in preparing the National AI Roadmap therefore provides empirical evidence of the multidimensional nature of technological governance in Indonesia⁶⁷. This situation challenges a conventional legislative structure, where regulatory authority is often distributed across sector-specific institutions⁶⁸.

A second limitation concerns regulatory fragmentation. Indonesia already possesses several legal instruments relevant to digital transformation. For example, the Personal Data Protection Law regulates principles, categories of personal data, data-subject rights, data processing, obligations of controllers and processors, cross-border transfers, administrative sanctions, institutional arrangements, public participation, dispute resolution, and criminal provisions. Meanwhile, AI-related governance has involved the interaction of existing

⁶⁷ Ministry of Communication and Digital Affairs of the Republic of Indonesia, “National Artificial Intelligence Roadmap 2026–2029 Involves More Than 30 Ministries and Government Institutions,” *JDIH Kementerian Komunikasi dan Digital*, 2026.

⁶⁸ rina Brass, “Adaptive Governance for the Internet of Things: Coping with Emerging Security Risks,” *Regulation & Governance* 15, no. 4 (2021): 1092–1110, <https://doi.org/10.1111/rego.12343>

information technology legislation, personal data protection regulation, sectoral regulation, ethical guidance, and emerging national AI policy instruments. The government itself has acknowledged the need to ensure that new AI instruments do not overlap with existing regulations and can be implemented coherently across ministries, government institutions, and industry.

This condition demonstrates that the principal regulatory problem is not necessarily the absence of legal norms. Rather, it concerns the coherence and interoperability of legal norms developed at different times and for different regulatory purposes. When technological applications implicate several regulatory fields simultaneously, sector-specific legislation may create overlapping obligations, different institutional authorities, or inconsistent regulatory standards. The result can be increased compliance costs, uncertainty concerning institutional responsibility, and difficulties in determining which regulatory framework should prevail in situations involving multiple technological risks⁶⁹.

A third limitation concerns conventional law-making's capacity to incorporate technological expertise. Drafting legislation on emerging technologies requires knowledge beyond traditional legal analysis. Policymakers must understand the technical characteristics of AI systems, data processing, algorithmic decision-making, cybersecurity, digital infrastructure, and emerging technological business models. The Indonesian government's current AI policy process illustrates this requirement. Preparing the National AI Roadmap has involved government institutions, industry, academics, associations, and other stakeholders through consultation and discussion. In August 2025, the Ministry of Communication and Digital reported that discussions on the AI roadmap involved seven working groups and that individual sessions could include approximately 300–350 participants.

This empirical development indicates a transition from a purely government-centered model toward a more multi-stakeholder regulatory

⁶⁹ Ujang Badru Jaman, Armansyah, and Thomas Sheku Marah, "Intellectual Property Governance in the Age of Artificial Intelligence: Regulatory Fragmentation and the Transformation of Digital Authority," *International Journal of Law in Changing World* 5, no. 1 (2026): 145–169, <https://doi.org/10.54934/ijlcw.v5i1.186>

process. Nevertheless, stakeholder participation should not be understood merely as a procedural requirement. In technology regulation, participation has a substantive function because technological actors, researchers, civil society organizations, consumers, and affected communities possess different forms of knowledge and experience. The challenge for legislative design is therefore to transform participation into a mechanism for improving the evidentiary and analytical quality of regulation⁷⁰.

A fourth limitation is the difficulty of applying a static regulatory model to technologies characterized by uncertainty and continuous development. The Indonesian government's current approach to AI illustrates this. In July 2026, the Ministry of Communication and Digital stated that the government intended to use a Presidential Regulation on AI as an initial step toward governance before developing a more comprehensive AI law. This staged approach reflects an attempt to regulate an emerging technology while recognizing that its development is still evolving. It also shows the practical need for a regulatory system that can learn from early regulatory experience before adopting a more comprehensive and permanent legislative framework.

From the perspective of Responsive Law Theory, this condition shows the need to move beyond a legal system that merely produces formally valid rules toward one that can respond substantively to changing social and technological conditions. The increasing adoption of digital technologies creates new interests, risks, and social relationships that the law-making process must recognize. Responsiveness therefore requires legislators and regulatory institutions to identify technological developments, understand their social consequences, and formulate legal responses that remain relevant as conditions change.

The same empirical evidence can also be interpreted through the lens of Adaptive Governance. The involvement of numerous ministries and institutions in preparing the National AI Roadmap indicates that technology governance increasingly requires coordination and institutional learning. The completion of interministerial discussions,

⁷⁰ David H. Guston, "The Anticipatory Governance of Emerging Technologies," *Journal of the Korean Vacuum Society* 19, no. 6 (2010): 432–441, <https://doi.org/10.5757/JKVS.2010.19.6.432>

public consultations, focus group discussions, and harmonization further indicates that the regulatory process is moving toward a more iterative and collaborative model. Nevertheless, these mechanisms need to be institutionalized beyond individual regulatory initiatives so that continuous learning and evaluation become inherent components of legislative design⁷¹.

The development of AI regulation also demonstrates the relevance of Anticipatory Governance. Rather than waiting until the social consequences of AI become fully established, Indonesian policymakers have begun developing a national roadmap and ethical governance framework while AI adoption continues to expand. In April 2026, the Ministry of Communication and Digital explicitly identified the need for stronger AI governance and risk mitigation in response to the growing use of AI and data, including concerns about misinformation, data breaches, and cybersecurity. This demonstrates a shift toward a more anticipatory regulatory orientation, in which potential risks are considered before they become fully institutionalized legal problems.

The empirical findings therefore reveal a significant paradox in Indonesia's legislative development. On the one hand, Indonesia has progressively improved its formal legislative framework. Law No. 13 of 2022, for example, strengthened meaningful public participation, introduced electronic legislation formation, incorporated the omnibus method, and revised academic text formulation and legislative drafting techniques⁷². However, technological transformation creates challenges that procedural improvements alone cannot resolve. The critical issue is whether the legislative process has sufficient technological foresight, interdisciplinary expertise, institutional coordination, evidence-based decision-making, and continuous evaluation to remain responsive after enactment.

The evidence consequently suggests that the limitation of conventional legislative design should not be understood as a failure of the Indonesian legislative system as a whole. Rather, the limitation lies in

⁷¹ Carl Folke, Thomas Hahn, Per Olsson, and Jon Norberg, "Adaptive Governance of Social-Ecological Systems," *Annual Review of Environment and Resources* 30 (2005): 441–473, <https://doi.org/10.1146/annurev.energy.30.050504.144511>

⁷² Republic of Indonesia, Law No. 13 of 2022 concerning the Second Amendment to Law No. 12 of 2011 concerning the Formation of Laws and Regulations.

the mismatch between a relatively structured and sequential legislative process and an increasingly dynamic, uncertain, and cross-sectoral technological environment. This distinction is important because the solution is not necessarily to abandon legal certainty or formal legislative procedures. Instead, the challenge is to introduce adaptive and anticipatory mechanisms within the existing rule-of-law framework.

Accordingly, transforming legislative design requires a shift from a model that primarily asks “What regulation should be enacted?” to a broader institutional question: “How should legislation be designed so that it can continue to respond effectively when technology, risks, and social conditions change?” The answer requires integrating regulatory adaptability, technological foresight, evidence-based lawmaking, interdisciplinary expertise, meaningful stakeholder participation, institutional coordination, and continuous regulatory evaluation.

This finding provides the basis for the next stage of the analysis. If Industry 4.0 has shown the limits of a predominantly static and reactive legislative model, the central question becomes how Indonesia can build an institutional design that learns, anticipates, and adapts to technological change. The following section therefore examines Adaptive and Anticipatory Legislative Governance as the foundation for developing a Technology-Responsive Regulatory Framework⁷³.

The foregoing analysis shows that Industry 4.0 has not only created new technological opportunities but has also exposed structural challenges in Indonesia’s existing legislative design. The rapid pace of technological development, the cross-sectoral nature of emerging technologies, regulatory fragmentation, limited technological expertise, and the need for continuous evaluation indicate that the challenge lies not merely in the substance of individual regulations, but also in the legislative process’s capacity to respond to technological transformation. In this context, it is necessary to identify more systematically the specific dimensions in which conventional legislative design struggles to govern Industry 4.0.

⁷³ Ministry of Communication and Digital Affairs of the Republic of Indonesia, “Artificial Intelligence Ethics and National AI Roadmap Discussed through Public Consultation, Focus Group Discussion, and Interministerial Harmonization,” *JDIH Kementerian Komunikasi dan Digital*, 2026.

The empirical conditions discussed in the preceding section can therefore be mapped into several interconnected dimensions. This mapping matters because it provides the analytical basis for distinguishing between the technological challenges generated by Industry 4.0 and the structural limitations of existing legislative design. The following table summarizes these relationships and provides the basis for the theoretical analysis developed in Section 4.2.

Table 1. Empirical Challenges of Indonesia’s Legislative Design in the Industry 4.0 Era

Dimension	Empirical Condition in Indonesia	Problem in Existing Legislative Design	Theoretical Interpretation	Regulatory Implication
Technological Dynamism	Rapid expansion of AI, big data, IoT, digital platforms, and automated systems	Legislation may become outdated before technological development stabilizes	Responsive Law	Legislation must be capable of responding to continuous technological change
Regulatory Timing	Technological innovation develops faster than conventional legislative processes	Regulatory time gap between technological development and legal intervention	Anticipatory Governance	Early identification, foresight, and technology assessment are required
Cross-Sectoral Technology	AI and digital technologies affect finance, health, education, public administration, employment, security, and other sectors	Sectoral regulation may produce fragmentation, overlap, and inconsistent regulatory standards	Adaptive Governance	Strengthen horizontal coordination and integrated regulatory design

Technological Expertise	Technology-related policy increasingly requires technical knowledge and interdisciplinary assessment	Conventional legal expertise alone may be insufficient to assess technological risks	Responsive Law + Adaptive Governance	Institutionalize technological and interdisciplinary expertise in law-making
Stakeholder Participation	AI governance development involves ministries, academics, industry, associations, and other stakeholders	Conventional participation may not sufficiently incorporate technological knowledge and affected interests	Responsive Law	Strengthen meaningful and substantive multi-stakeholder participation
Regulatory Uncertainty	Emerging technologies create risks and consequences that cannot always be predicted	Excessively rigid rules may become obsolete, while excessive flexibility may reduce legal certainty	Responsive Law + Adaptive Governance	Balance legal certainty with regulatory adaptability
Regulatory Evaluation	Technological conditions may change after regulations are enacted	Legislation may lack sufficient mechanisms for continuous adjustment	Adaptive Governance	Institutionalize monitoring, post-implementation evaluation, and periodic regulatory review
Emerging Technological Risks	AI and data-driven technologies generate new issues concerning privacy, security, accountability, and fundamental rights	Reactive regulation may address risks only after significant consequences emerge	Anticipatory Governance	Integrate risk assessment, foresight, and preventive regulatory intervention

Source: OECD (2024); OECD (2025); UNESCO (2021); Law No. 13 of 2022; Constitutional Court Decision No. 91/PUU-XVIII/2020; Author Analysis.

The mapping presented above reveals that the limitations of Indonesia's existing legislative design are multidimensional. They are reflected not only in the speed of law-making but also in the sectoral structure of regulation, the availability of technological expertise, the quality of stakeholder participation, the management of regulatory uncertainty, and the absence of sufficiently institutionalized mechanisms for continuous evaluation⁷⁴. These conditions suggest that the conventional legislative model is increasingly confronted with a regulatory environment characterized by speed, complexity, uncertainty, and technological interdependence⁷⁵.

Accordingly, this section moves beyond identifying regulatory gaps and focuses on a more fundamental question: why conventional legislative design is insufficient to respond to Industry 4.0. This section examines this question through the perspectives of Responsive Law, Adaptive Governance, and Anticipatory Governance. These perspectives offer complementary analytical lenses for understanding the transformation required: responsiveness to changing social and technological realities, institutional capacity to learn and adapt, and the ability to anticipate emerging technological developments and risks.

The development of Industry 4.0 has generated rapid technological and social transformations that challenge the capacity of conventional legislative design to respond effectively to emerging legal issues⁷⁶. Technologies such as artificial intelligence, big data, the Internet of Things, blockchain, cloud computing, robotics, and automated decision-making develop at a pace that is often faster than the legislative process. As a result, the central challenge is no longer whether new technologies require regulation, but whether the existing legislative

⁷⁴ OECD, *Framework for Anticipatory Governance of Emerging Technologies*, OECD Science, Technology and Industry Policy Papers, no. 165 (Paris: OECD Publishing, 2024), <https://doi.org/10.1787/0248ead5-en>.

⁷⁵ Walter G. Johnson, "Caught in Quicksand? Compliance and Legitimacy Challenges in Using Regulatory Sandboxes to Manage Emerging Technologies," *Regulation & Governance* 17, no. 3 (2023): 709–725, <https://doi.org/10.1111/rego.12487>.

⁷⁶ OECD, *OECD Regulatory Policy Outlook 2025* (Paris: OECD Publishing, 2025), <https://doi.org/10.1787/56b60e39-en>

design can respond to technological change in a timely, coherent, and legitimate manner.

The first challenge concerns the speed of technological change. Conventional legislative processes generally require several stages, including planning, drafting, harmonization, discussion, enactment, and implementation. These stages ensure legal certainty and democratic legitimacy, but they may create a temporal gap between technological development and regulatory intervention. When regulation is formulated only after a technology has become widely adopted, the law may address problems that have already evolved or become more complex. Consequently, legislation risks becoming reactive rather than preventive⁷⁷.

The second challenge relates to the complexity of Industry 4.0 technologies. Technological developments frequently involve technical, economic, social, ethical, and legal dimensions simultaneously. Artificial intelligence, for example, is not merely an information technology issue because its application may affect personal data protection, employment, consumer protection, administrative decision-making, liability, intellectual property, and fundamental rights. This complexity makes a purely sectoral legislative approach increasingly difficult to maintain. A regulation designed within one institutional or sectoral boundary may generate consequences that extend beyond that boundary.

The third challenge is regulatory uncertainty arising from fragmentation. New technologies may involve several regulatory authorities and different legal instruments. Without adequate coordination, this situation can produce overlapping mandates, inconsistent standards, regulatory gaps, and uncertainty for citizens, businesses, and public institutions. Fragmentation therefore is not merely a technical problem of legislative drafting; it reflects a deeper problem with the regulatory system's capacity to understand and govern technologies that operate across institutional and sectoral boundaries.

Another important limitation concerns technological expertise in the legislative process. Effectively regulating Industry 4.0 requires

⁷⁷ Jacob A. Hasselbalch, "Innovation Assessment: Governing through Periods of Disruptive Technological Change," *Journal of European Public Policy* 25, no. 12 (2018): 1813–1832, <https://doi.org/10.1080/13501763.2017.1363805>

legislators and policymakers to understand not only legal principles but also the characteristics, opportunities, limitations, and risks of emerging technologies. A legislative process dominated by conventional legal expertise, without sufficient technological knowledge, may produce rules that are either too general to be effective or too rigid to accommodate technological innovation. Therefore, technological expertise should become an integral component of contemporary legislative design rather than merely an external source of consultation.

The same issue applies to public and stakeholder participation. Technological regulation affects a broad range of actors, including government institutions, businesses, technology developers, academics, professional communities, and society. Meaningful participation is therefore important not only to strengthen democratic legitimacy but also to provide the information and practical knowledge required for effective regulation. Participation should move beyond formal consultation toward a process in which relevant stakeholders can contribute substantive knowledge concerning technological development, potential risks, social consequences, and regulatory alternatives.

Conventional legislative design also has limited capacity for continuous regulatory evaluation⁷⁸. Conventional legislation is often understood as a relatively stable legal product that remains applicable until it is formally amended or replaced. This approach becomes problematic in an environment where technological conditions change continuously. Regulation appropriate when enacted may become inadequate as technology, business models, risks, and social practices evolve. Continuous evaluation is therefore necessary to determine whether regulation remains relevant, effective, proportionate, and able to protect public interests.

These challenges can be understood through the perspective of Responsive Law Theory. Responsive law emphasizes the law's capacity to respond to changing social realities rather than treating legal rules as

⁷⁸ Walter G. Johnson, "Adapting Regulatory Sandboxes as Experimentalist Governance Frameworks for Public Sector Artificial Intelligence Experimentation," *Global Public Policy and Governance* 6 (2026): 259–281, <https://doi.org/10.1007/s43508-026-00147-x>

autonomous, static instruments. In the context of Industry 4.0, responsiveness requires legislative institutions to recognize technological transformation as an ongoing social reality and incorporate it into the law-making process. The law must therefore be sufficiently flexible to accommodate legitimate technological innovation while maintaining legal certainty, accountability, and protection of fundamental rights.

However, responsiveness alone is insufficient. The rapidly changing nature of technology also requires the regulatory system to possess the capacity for institutional learning, flexibility, coordination, and adjustment⁷⁹. This is the contribution of Adaptive Governance. An adaptive legislative system does not assume that every regulatory problem can be fully understood and solved when legislation is enacted. Instead, it recognizes uncertainty as an inherent feature of technological development and establishes mechanisms for regulation to learn from implementation, stakeholder experiences, new evidence, and technological developments.

Furthermore, technological regulation requires the capacity to identify and address risks before they become widespread social problems. This dimension is explained through Anticipatory Governance, which emphasizes foresight, technological assessment, stakeholder engagement, and early intervention. In the context of Industry 4.0, anticipatory governance requires legislators to consider not only existing technological applications but also their possible future trajectories, potential risks, and long-term societal implications. Consequently, legislation should not merely respond to technological problems that have already occurred but should also develop mechanisms for anticipating emerging risks.

Integrating these three theoretical perspectives shows that the fundamental transformation required is a shift from reactive legislative design to adaptive, anticipatory, and responsive legislative design. Responsive Law provides the normative foundation for ensuring that legislation remains connected to changing social and technological realities. Adaptive Governance provides the institutional capacity for learning, coordination, flexibility, and continuous adjustment.

⁷⁹ Philippe Nonet and Philip Selznick, *Law and Society in Transition: Toward Responsive Law* (New York: Harper & Row, 1978).

Anticipatory Governance provides the forward-looking capacity necessary to identify technological developments and risks before they generate significant regulatory problems.

This transformation leads to the need for a Technology-Responsive Regulatory Framework. Such a framework should be constructed around several interconnected dimensions. First, regulatory adaptability is required so that legal instruments can adjust to technological developments without continuously relying on lengthy legislative amendments. Second, technological anticipation is necessary to identify emerging technologies and potential risks early. Third, evidence-based law-making should ensure that regulatory decisions are supported by empirical evidence, technological assessment, and regulatory impact analysis rather than solely by normative assumptions.

Fourth, legislative processes must integrate technological expertise through interdisciplinary engagement among legal scholars, legislators, policymakers, technology experts, industry, and other relevant stakeholders. Fifth, meaningful participation should give affected communities and stakeholders opportunities to contribute substantively to regulatory formulation. Sixth, continuous evaluation should become an institutionalized mechanism for assessing whether existing regulations remain effective and relevant amid technological change⁸⁰.

Accordingly, the limitations of conventional legislative design should not be interpreted as a reason to abandon legal certainty or democratic legislative procedures. Rather, they show the need to reconfigure how legal certainty and democratic legitimacy are achieved in an environment characterized by technological uncertainty and rapid change. The legislative process must remain legally accountable while simultaneously becoming more flexible, evidence-based, technologically informed, participatory, and future-oriented.

Thus, this study argues that Industry 4.0 requires Indonesia to move beyond a legislative paradigm that primarily reacts to technological developments toward a Technology-Responsive Legislative Design. Such a design integrates responsiveness, adaptability, anticipation, technological expertise, meaningful participation, evidence-based

⁸⁰ David H. Guston, "Understanding 'Anticipatory Governance,'" *Social Studies of Science* 44, no. 2 (2014): 218–242, <https://doi.org/10.1177/0306312713508669>.

decision-making, and continuous regulatory evaluation. This framework provides the conceptual foundation for the next discussion concerning how adaptive and anticipatory legislative governance can be institutionalized within Indonesia's regulatory system.

To conclude Subsection 4.2, the final part should not merely summarize but rather reinforce the analytical findings and serve as a strong bridge to Section 4.3 on Adaptive and Anticipatory Legislative Governance. I suggest using the following wording: Concluding Analysis of Section 4.2

The analysis shows that the limitations of Indonesia's conventional legislative design in the Industry 4.0 era stem from a mismatch between the dynamic pace of technological development and the relatively static architecture of lawmaking. The existing legislative process remains essential for ensuring legal certainty, democratic legitimacy, and accountability; however, its conventional structure is not sufficiently equipped to address technologies that develop rapidly, operate across sectoral boundaries, generate uncertain risks, and continuously transform social and economic relations.

From the perspective of Responsive Law, this condition indicates that legislation must become more sensitive to changing technological and social realities. Responsiveness should not be understood merely as the ability to formulate new regulations after technological problems emerge, but as the institutional capacity to continuously understand social transformation and translate technological developments into appropriate legal responses. Law must therefore remain sufficiently open to change while preserving its fundamental functions of certainty, justice, and protection of rights.

At the same time, Adaptive Governance demonstrates that responsiveness requires institutional mechanisms capable of learning and adjustment. Technological uncertainty cannot always be resolved through detailed and rigid rules at the initial stage of regulation. Instead, regulatory institutions need mechanisms to monitor implementation, evaluate regulatory outcomes, coordinate across institutional boundaries, incorporate new evidence, and adjust regulatory responses as technological circumstances change. Adaptability thus becomes an essential characteristic of contemporary legislative design.

Anticipatory Governance further expands this approach by emphasizing the importance of looking beyond existing technological applications to possible future developments and their societal consequences. Legislative design should therefore incorporate foresight, technological assessment, risk identification, and early stakeholder engagement. Such an approach enables regulation to intervene before emerging technological risks become systemic legal and social problems.

Taken together, these three perspectives indicate that the principal weakness of conventional legislative design is not simply its inability to regulate new technologies, but its limited capacity to respond, learn, anticipate, and adapt continuously. The challenge is consequently one of institutional and legislative design rather than merely regulatory substance. Industry 4.0 requires a transformation that incorporates technological change into the architecture of law-making itself.

Therefore, the transformation required is not a replacement of conventional legislative mechanisms, but their reconstruction into a more responsive, adaptive, and anticipatory system. Such transformation requires regulatory adaptability, technological foresight, evidence-based law-making, technological expertise, meaningful stakeholder participation, institutional coordination, and continuous regulatory evaluation. These elements provide the foundation for developing a Technology-Responsive Regulatory Framework capable of maintaining legal certainty and democratic legitimacy while simultaneously responding to the speed, complexity, and uncertainty of technological transformation.

This conclusion sets up the next section, which examines how adaptive and anticipatory legislative governance can be developed as an institutional response to the limitations identified above. Section 4.3 therefore moves from diagnosing the limitations of conventional legislative design to formulating a governance model that makes Indonesian law-making more adaptive, anticipatory, evidence-based, and technologically responsive.

C. Toward Adaptive and Anticipatory Legislative Governance

The limitations identified in the previous section show that regulating Industry 4.0 cannot rely exclusively on a conventional legislative model that responds to technological developments only after legal problems have emerged. The increasing speed, complexity, and cross-sectoral character of emerging technologies require a transformation in the way regulation is designed, formulated, implemented, and evaluated. The central issue is therefore not simply whether Indonesia needs more technology-related regulations, but whether its legislative governance has sufficient capacity to learn continuously from technological developments, anticipate emerging risks, coordinate across institutional boundaries, and adjust regulatory responses without sacrificing legal certainty and democratic legitimacy.

This need for transformation has become increasingly evident in Indonesia's digital development. The Indonesian digital economy was valued at approximately USD 90 billion in 2024 and is projected to reach USD 360 billion by 2030. The scale of this transformation demonstrates that technological development is no longer a marginal issue confined to the information and communication technology sector. It increasingly affects finance, trade, public administration, education, health, employment, transportation, and other areas of social and economic life. The regulatory system therefore needs to evolve in parallel with technological transformation rather than treating technological regulation as a series of isolated sectoral interventions.

One important indication of this transformation is the Indonesian government's development of a national governance framework for artificial intelligence. In February 2026, the Ministry of Communication and Digital reported that the formulation of the Draft Presidential Regulation on the National Artificial Intelligence Roadmap 2026–2029 involved more than 30 ministries and government agencies, including the Ministry of National Development Planning/Bappenas, the Ministry of Finance, and the National Research and Innovation Agency (BRIN). The process aimed to set strategic directions for developing and using AI in Indonesia ethically, safely, inclusively, and responsibly.

This development matters because it signals a shift away from a purely sectoral regulatory approach toward more coordinated regulatory governance. The involvement of more than 30 ministries and agencies indicates that AI is increasingly understood as a cross-cutting policy issue rather than something that belongs exclusively to one regulatory institution. From an adaptive governance perspective, such institutional coordination matters because complex technological systems cannot be governed effectively through isolated institutional responses. Adaptive governance requires interaction among multiple actors, knowledge exchange, institutional learning, and the capacity to modify governance arrangements as circumstances change. Folke and colleagues conceptualize adaptive governance as the capacity of governance systems to manage complexity and change through learning, collaboration, and institutional flexibility.

The Indonesian experience also shows that adaptive governance is gradually being incorporated into regulatory development. In May 2026, the Ministry of Communication and Digital reported that the draft Presidential Regulations on AI Ethics and the National AI Roadmap 2026–2029 had undergone cross-ministerial discussions, public consultation, stakeholder-focused discussions, and harmonization. The stated objective was, among other things, to ensure that AI-related legal instruments would not overlap with existing regulations and could be implemented effectively across ministries, government agencies, and industry.

This process illustrates an important shift in legislative governance. Regulatory formulation is no longer understood exclusively as producing a legal text, but increasingly as a process of coordination, consultation, knowledge integration, and institutional adjustment. This corresponds closely with the logic of Adaptive Governance. Rather than assuming that one institution possesses sufficient information to design an optimal regulatory response, adaptive governance recognizes that knowledge about emerging technologies is distributed among government institutions, scientists, technology developers, industry, civil society, and affected communities.

From the perspective of Responsive Law, this development also reflects an important transformation. Nonet and Selznick's concept of responsive law emphasizes the need for legal institutions to take social

realities, social needs, and the consequences of official action seriously. Their work positions responsive law as a movement beyond an autonomous legal order toward institutions that can respond intelligently to changing social conditions. In the context of Industry 4.0, technological transformation is one of the most significant changing social realities the legal system must address.

The relevance of Responsive Law becomes particularly clear when technological development creates legal consequences that were not contemplated when existing legislation was formulated. Artificial intelligence, for example, can affect privacy, discrimination, consumer protection, employment, administrative decision-making, intellectual property, cybersecurity, and liability at the same time. A responsive legislative system therefore cannot simply ask whether an existing legal rule applies to a new technology. It must also ask whether the existing legal framework remains substantively appropriate in light of technological change.

Indonesia's recent approach to AI regulation shows this emerging responsiveness. In July 2026, the Ministry of Communication and Digital said the planned Presidential Regulation on AI would be an initial step toward more comprehensive AI legislation. The government described this as a gradual approach in which the Presidential Regulation would serve as an initial regulatory "test case" before developing a broader AI law.

This approach is particularly relevant to adaptive regulation. Rather than immediately establishing a comprehensive, highly detailed regulatory framework in an environment marked by technological uncertainty, the government is developing an initial regulatory instrument that provides a governance foundation while leaving room for further regulatory development. This can be interpreted as an emerging form of regulatory learning: regulation is introduced, its implementation generates experience and evidence, and subsequent legal instruments can be developed on that basis.

Nevertheless, such an approach must be carefully designed. Responsiveness and adaptability should not justify regulatory uncertainty or unlimited administrative discretion. Nonet and Selznick themselves recognize that responsive law is a high-risk mode of governance because excessive flexibility may weaken the law's authority

and predictability. Responsive institutions therefore require competence and institutional mechanisms capable of identifying social needs and translating them into legitimate legal responses. The Indonesian challenge is consequently to develop regulatory flexibility without sacrificing the rule of law.

This is where Anticipatory Governance becomes particularly important. Adaptive governance primarily emphasizes the capacity to learn and adjust to changing conditions. In contrast, anticipatory governance adds the capacity to look ahead and identify possible technological trajectories and risks before they become entrenched. Guston's conception of anticipatory governance emphasizes the importance of foresight, engagement, and governing emerging technologies before their social consequences become fully established.

The OECD's 2024 Framework for Anticipatory Governance of Emerging Technologies provides a particularly useful analytical reference. It identifies five interconnected elements: embedding values throughout the innovation process; strengthening foresight and technology assessment; engaging stakeholders and society; developing agile and adaptive regulation; and reinforcing international cooperation. These elements provide a useful framework for evaluating Indonesia's emerging legislative response to Industry 4.0.

First, foresight and technology assessment should become part of the early stages of legislative planning. Conventional legislative processes tend to begin with an identified legal or social problem. In the context of emerging technologies, however, waiting until a problem has fully materialized may delay intervention. Legislative institutions should therefore develop mechanisms for horizon scanning, technological assessment, scenario analysis, and early identification of potential legal and social consequences.

This approach is increasingly important in the context of AI. In August 2026, the Ministry of Communication and Digital highlighted that AI was entering a phase in which systems could increasingly plan, make decisions, and execute actions autonomously. This development raises new questions concerning accountability, transparency, and human oversight. The regulatory significance is that legal institutions cannot wait until autonomous AI systems become fully embedded in

critical sectors before considering how to allocate responsibility and design oversight mechanisms.

Second, stakeholder participation should shift from a procedural requirement to a source of regulatory knowledge. Indonesia has already moved in this direction by strengthening meaningful participation in legislation formation. Law No. 13 of 2022 amended Law No. 12 of 2011, explicitly strengthened meaningful public participation, introduced the possibility of electronic legislation formation, and incorporated the omnibus method into Indonesian legislative practice.

The significance of meaningful participation in technology regulation extends beyond democratic legitimacy. In rapidly evolving technological fields, government institutions may lack the technical information needed to anticipate technological consequences. Technology developers understand technical trajectories; industry actors understand operational realities; academics contribute independent analysis; civil society identifies social and rights-related implications; and affected communities provide experiential knowledge. Consequently, meaningful participation can function as an epistemic mechanism through which legislative institutions improve the quality of regulatory knowledge⁸¹.

Third, inter-institutional coordination must become a permanent characteristic of technology governance. Indonesia's cross-ministerial AI roadmap illustrates this need. The involvement of more than 30 ministries and agencies shows how emerging technology transcends conventional institutional boundaries.

From an Adaptive Governance perspective, however, coordination should not be limited to temporary inter-ministerial meetings. It should be institutionalized through mechanisms for information sharing, joint regulatory assessment, interoperable regulatory databases, coordinated monitoring, and clearly defined institutional responsibilities. Otherwise, coordination may remain dependent on ad hoc initiatives and may not adequately address future technological developments.

⁸¹ Irina Brass and Jesse H. Sowell, "Adaptive Governance for the Internet of Things: Coping with Emerging Security Risks," *Regulation & Governance* 15, no. 4 (2021): 1092–1110, DOI 10.1111/regg.12343.

Fourth, evidence-based law-making should become an essential component of adaptive and anticipatory legislative governance⁸². Emerging technology creates significant uncertainty, and normative assumptions alone cannot adequately manage it. Regulatory decisions should therefore be supported by empirical evidence, technology assessment, impact analysis, stakeholder knowledge, and implementation data⁸³. The objective is not to eliminate uncertainty, which is impossible in the context of emerging technologies, but to make regulatory decisions more informed and capable of being revised when new evidence emerges⁸⁴.

Fifth, agile regulation is necessary to bridge the tension between regulatory certainty and technological uncertainty. Agile regulation does not mean legal rules should become unstable or change continuously. Rather, it means the regulatory system should include structured mechanisms to monitor, evaluate, interpret, and adjust rules in response to demonstrable changes in technology and social conditions. The OECD similarly emphasizes agile, adaptive regulation as a core component of anticipatory governance for emerging technologies.

In this respect, the Indonesian government's gradual approach to AI regulation is analytically significant. The decision to establish an initial Presidential Regulation before considering a more comprehensive AI law can be seen as an attempt to build a regulatory foundation while allowing policymakers to gain experience and evidence. However, this approach should include explicit evaluation mechanisms, because experimentation without institutional learning risks producing temporary regulation without a clear pathway to improvement.

Sixth, legislative governance must incorporate continuous regulatory evaluation. The conventional model often treats enactment as the culmination of the legislative process. In an adaptive regulatory model, enactment marks the start of another cycle of implementation, monitoring, evaluation, learning, and revision. This shifts the conceptual

⁸² Brass and Sowell, "Adaptive Governance for the Internet of Things," 1092–1110.

⁸³ Lauren Fahy, "Regulator Reputation and Stakeholder Participation: A Case Study of the UK's Regulatory Sandbox for Fintech," *European Journal of Risk Regulation* 13, no. 1 (2022): 138–157, DOI 10.1017/err.2021.44

⁸⁴ Philippe Nonet and Philip Selznick, *Law and Society in Transition: Toward Responsive Law* (New York: Harper & Row, 1978).

relationship between legislation and technological development: legislation is no longer a final product but part of an ongoing governance process.

Integrating these dimensions shows that Adaptive Governance and Anticipatory Governance should not operate independently. Anticipatory governance provides the forward-looking capacity to identify emerging technologies, risks, and possible futures. Adaptive governance provides the institutional capacity to learn from implementation and adjust regulatory responses. Responsive Law provides the normative orientation that ensures such adaptation remains connected to social needs, public interests, justice, and the protection of rights.

The relationship can therefore be conceptualized as follows:

- a. Responsive Law provides the normative question: *What social and technological realities should law respond to?*
- b. Anticipatory Governance provides the forward-looking question: *What technological developments and risks should law prepare for before they become entrenched?*
- c. Adaptive Governance provides the institutional question: *How should regulatory institutions learn, coordinate, evaluate, and adjust when technological conditions change?*

Combining these three approaches produces a different understanding of legislative governance. The objective is not simply to speed up lawmaking. Speed alone does not guarantee good regulation. Instead, legislative governance must be responsive in orientation, anticipatory in assessing future developments, and adaptive in its institutional mechanisms.

This distinction matters for Indonesia because the rapid expansion of digital technology creates both opportunities and risks. Projected growth in the digital economy underscores the economic importance of technological innovation, while the government's continued development of AI governance reflects the growing complexity of the regulatory challenge. An excessively rigid regulatory system may constrain innovation, whereas an excessively permissive one may fail to protect rights and public interests. The appropriate response is therefore not deregulation or overregulation, but a regulatory architecture that balances innovation, certainty, accountability, and protection.

The analysis consequently suggests that Indonesia is already moving toward elements of adaptive and anticipatory legislative governance, but these elements remain emergent rather than fully institutionalized. The development of the National AI Roadmap, cross-ministerial coordination, public consultation, regulatory harmonization, and the gradual approach toward comprehensive AI legislation demonstrate significant movement in this direction. Nevertheless, these practices must shift from individual policy initiatives to a more systematic legislative architecture.

Such an architecture should institutionalize at least six core capacities: (1) technological foresight and horizon scanning; (2) interdisciplinary technological expertise; (3) meaningful stakeholder participation; (4) evidence-based and impact-oriented law-making; (5) adaptive and coordinated regulatory mechanisms; and (6) continuous post-enactment evaluation. These capacities would allow the legislative system to respond not only to existing technologies but also to emerging technological trajectories whose legal and social implications remain uncertain.

The theoretical implication is that Responsive Law, Adaptive Governance, and Anticipatory Governance should be understood as complementary rather than competing frameworks. Responsive Law explains the normative need to connect law to changing social realities. Adaptive Governance explains the institutional capacity required to learn and adjust under conditions of complexity and uncertainty. Anticipatory Governance adds the temporal dimension by requiring legal institutions to consider future technological developments and intervene before risks become entrenched. Their integration therefore provides a stronger theoretical foundation for redesigning legislative governance in the Industry 4.0 era.

Accordingly, the transition toward adaptive and anticipatory legislative governance represents a shift from reactive regulation toward continuous regulatory learning and forward-looking legal design. The ultimate objective is not to predict the future with certainty, but to build legislative institutions that can recognize emerging signals, assess possible consequences, engage relevant stakeholders, respond to new evidence, and adjust regulatory instruments while maintaining legal certainty and democratic accountability.

This finding provides the conceptual foundation for the next stage of the analysis. If Section 4.2 establishes that conventional legislative design is insufficient for the speed, complexity, and uncertainty of Industry 4.0, and Section 4.3 demonstrates the need for adaptive and anticipatory governance, the next question is how to translate these principles into a coherent Technology-Responsive Regulatory Framework for Indonesia. Section 4.4 therefore develops the proposed framework by integrating regulatory adaptability, technological anticipation, evidence-based law-making, technological expertise, meaningful participation, and continuous regulatory evaluation into a unified model of legislative design.

D. A Technology-Responsive Regulatory Framework for Indonesia

The preceding analysis shows that the transformation brought about by Industry 4.0 requires more than developing additional technology-specific regulations. It requires transforming the architecture of legislative design itself. The rapid development of artificial intelligence, big data, the Internet of Things, blockchain, cloud computing, automation, and other emerging technologies creates regulatory challenges that cannot be adequately addressed through a legislative model that is predominantly reactive, sectoral, static, and dependent upon conventional sources of legal expertise.

This study therefore proposes developing a Technology-Responsive Regulatory Framework for Indonesia. This framework is designed not to replace the existing legislative system, but to transform its regulatory capacity. Its purpose is to ensure that legislation remains responsive to technological and social change while maintaining the fundamental values of legal certainty, democratic legitimacy, accountability, justice, and protection of fundamental rights.

The framework rests on three theoretical perspectives: Responsive Law, Adaptive Governance, and Anticipatory Governance. These theories perform different but complementary functions. Responsive Law provides the normative foundation for keeping law connected to changing social and technological realities. Adaptive Governance

provides the institutional mechanism through which regulatory systems can learn, coordinate, monitor, and adjust. Anticipatory Governance provides the forward-looking capacity to identify emerging technologies, assess potential consequences, and intervene before technological risks become entrenched.

Accordingly, the proposed framework does not understand legislative responsiveness as simply the government's ability to produce regulations more quickly. Responsiveness is the legal system's capacity to continuously perceive technological change, interpret its social consequences, anticipate emerging risks, incorporate relevant knowledge, and adjust regulatory responses through legitimate institutional processes. This distinction matters because accelerating the legislative process without strengthening its knowledge base and institutional capacity may produce regulations that are faster but not necessarily better.

The first dimension of the proposed framework is regulatory adaptability. Conventional legislation tends to assume that the circumstances underlying regulation will remain relatively stable. Industry 4.0 challenges this assumption because technological systems, business models, and patterns of social interaction may change substantially within a relatively short period. Regulatory adaptability therefore requires legal instruments to contain mechanisms that enable adjustment without undermining legal certainty.

Adaptability may be achieved through a combination of principles-based regulation, delegated regulatory instruments, technical standards, periodic review clauses, regulatory guidance, and other legally accountable mechanisms that permit detailed requirements to evolve as technological conditions change. The objective is not to make regulation unstable, but to create a controlled capacity for regulatory adjustment. In this sense, adaptability institutionalizes law's learning function.

The second dimension is technological anticipation. A technology-responsive legislative system should not wait until technological risks have materialized before considering their legal implications. Legislative planning should therefore incorporate horizon scanning, technology assessment, foresight exercises, scenario analysis, and early risk identification.

This dimension is particularly important for emerging technologies such as artificial intelligence. The development of increasingly autonomous AI systems demonstrates that legal institutions must consider not only current applications but also possible future capabilities and consequences. Questions concerning human oversight, accountability, transparency, discrimination, privacy, safety, and liability may need to be addressed before the technology becomes deeply embedded in critical social and economic systems.

Technological anticipation therefore changes the temporal orientation of legislation. Instead of asking only “What legal problem exists today?”, legislative institutions should also ask “What technological developments are likely to emerge, what consequences may they generate, and what legal safeguards should be prepared in advance?” This represents the central contribution of Anticipatory Governance to the proposed framework.

The third dimension is evidence-based law-making. Technological uncertainty makes it difficult for legislators to rely exclusively on conventional legal reasoning. Regulatory decisions concerning Industry 4.0 should be informed by empirical evidence, technological assessment, regulatory impact analysis, implementation experience, and comparative knowledge.

Evidence-based law-making is particularly important because technological regulation involves significant trade-offs. Excessive regulation may constrain innovation and economic development, whereas insufficient regulation may expose society to significant risks. Evidence can therefore help legislators assess the proportionality of regulatory intervention and determine whether a particular risk requires prohibition, restriction, supervision, disclosure, standards, incentives, or other regulatory responses.

This dimension also strengthens the relationship between Responsive Law and Adaptive Governance. Responsive law requires the legal system to understand changing social realities, while adaptive governance requires institutions to learn from experience. Evidence provides the informational foundation through which both processes can operate. Without reliable evidence, responsiveness may become merely political reaction, while adaptation may become discretionary adjustment without a sufficiently rational basis.

The fourth dimension is technological expertise. The complexity of Industry 4.0 means contemporary legislative governance cannot be adequately carried out through legal expertise alone. Formulating technology-related regulation requires interaction among legal scholars, legislators, policymakers, engineers, computer scientists, economists, ethicists, industry practitioners, civil society organizations, and other relevant actors.

Technological expertise should therefore be integrated into the legislative process from the early stages of regulatory planning rather than introduced only after the substantive direction of regulation has already been determined. Expert participation should help identify technological trajectories, assess risks, evaluate regulatory alternatives, and explain the likely consequences of proposed legal interventions.

This approach aligns with Adaptive Governance because knowledge about complex technologies is distributed across multiple institutions and social actors. No single regulatory institution can reasonably be expected to possess all of the knowledge necessary to govern rapidly evolving technologies. Institutional capacity must therefore be constructed through knowledge networks and interdisciplinary collaboration.

The fifth dimension is meaningful participation. Participation in technology-related law-making should not be treated merely as a procedural requirement to satisfy formal legislative obligations. It should function as a substantive mechanism for improving the quality and legitimacy of regulation.

Meaningful participation matters in emerging technology governance because the consequences of technological regulation are unevenly distributed among stakeholders. Technology companies may understand innovation trajectories and implementation challenges; government institutions possess administrative knowledge; academics provide independent analysis; civil society organizations can identify human rights and social justice concerns; and affected communities can offer knowledge of regulation's practical consequences.

Meaningful participation therefore serves two functions simultaneously. First, it strengthens democratic legitimacy, consistent with Responsive Law's normative orientation. Second, it improves the epistemic quality of regulation, consistent with Adaptive and

Anticipatory Governance. Participation thus becomes not merely a democratic procedure but also a source of knowledge for regulatory decision-making.

The sixth dimension is continuous regulatory evaluation. One of the most significant changes this framework proposes concerns the relationship between enactment and evaluation. Under a conventional legislative paradigm, enactment is often treated as the culmination of the law-making process. Under a technology-responsive paradigm, enactment represents the beginning of an ongoing regulatory cycle.

This cyclical structure transforms regulation from a static legal product into a continuous governance process. Evaluation should examine whether regulation remains effective, whether unintended consequences have emerged, whether technological conditions have changed, whether rights are adequately protected, and whether regulatory burdens remain proportionate to the risks being addressed.

Continuous evaluation is therefore the principal mechanism connecting Adaptive Governance with the legislative process. It enables the regulatory system to learn from implementation rather than assuming that the original legislative design will remain appropriate indefinitely.

These six dimensions should not be understood as independent components. They form an interconnected regulatory architecture. Technological anticipation identifies future developments and risks; technological expertise provides the knowledge necessary to understand them; evidence-based law-making converts knowledge into regulatory choices; meaningful participation provides democratic legitimacy and additional knowledge; regulatory adaptability enables the legal framework to adjust to changing conditions; and continuous evaluation generates institutional learning for subsequent regulatory intervention.

That section should no longer be presented as a schematic; instead, it should be expanded into an academic narrative explaining the transformation process from conventional legislative design to a Technology-Responsive Regulatory Framework. Below is a more fluid formulation suitable for placement at the end of Subsection 4.4. The Transformation toward a Technology-Responsive Legislative Design

The Technology-Responsive Regulatory Framework proposed in this study begins with the recognition that technological change is a

continuous process rather than a temporary phenomenon. Industry 4.0 continuously generates new technologies, applications, business models, and forms of social interaction. Consequently, the legislative system cannot rely solely on existing knowledge and previously identified legal problems. A technology-responsive legislative process must therefore begin with continuous observation of technological developments and their potential legal, economic, social, and ethical consequences.

This requires the legislative system to develop the capacity for horizon scanning and technological anticipation. Horizon scanning enables legislative and regulatory institutions to identify emerging technologies and developments that may generate future regulatory consequences. The purpose is not to predict the future with absolute certainty, but to identify possible technological trajectories and potential risks early on. Through this process, legislative institutions can better prepare to formulate appropriate regulatory responses before technological risks become widespread or difficult to control.

The information generated through technological anticipation must then be supported by interdisciplinary expertise and meaningful stakeholder participation. Emerging technologies are too complex to understand from a legal perspective alone. Their regulation requires interaction between legal experts and specialists in technology, economics, ethics, public policy, industry, and other relevant fields. At the same time, stakeholders and affected communities must be involved because they have practical knowledge of how technology is applied and its consequences⁸⁵. This interaction allows the legislative process to build a broader, more reliable knowledge base.

The next stage is developing an evidence-based regulatory assessment. Information from technology experts, stakeholders, empirical research, and technology assessments should be transformed into evidence to support legislative decision-making. At this stage, policymakers should examine the nature of the technological development, its potential benefits and risks, affected interests, possible impacts on fundamental rights, and alternative regulatory responses. The

⁸⁵ Walter G. Johnson, “Caught in Quicksand? Compliance and Legitimacy Challenges in Using Regulatory Sandboxes to Manage Emerging Technologies,” *Regulation & Governance* 17, no. 3 (2023): 709–725, DOI 10.1111/rego.12487

objective is to ensure that regulatory intervention is not based merely on assumptions or reactions to technological disruption, but on systematic assessment and evidence.

The results of this assessment then become the foundation for Technology-Responsive Legislative Design. At this stage, the legislative process continues to perform its conventional functions of planning, drafting, discussion, enactment, and promulgation. However, these processes are informed by technological foresight, interdisciplinary knowledge, empirical evidence, and stakeholder participation. Consequently, the legislative product is expected to be more capable of addressing technological developments while maintaining legal certainty, democratic legitimacy, accountability, and protection of fundamental rights⁸⁶.

Once legislation has been enacted, the regulatory process does not end. The next stage is adaptive regulatory implementation. Implementation must recognize that the technological environment may continue to change after enactment. Regulatory institutions therefore need sufficient capacity to monitor implementation, identify new developments, detect unintended consequences, and respond to changing circumstances. Adaptation, however, must remain within the boundaries of legality and accountability so that flexibility does not become arbitrary administrative discretion⁸⁷.

This stage is followed by monitoring and continuous evaluation. Regulators should assess effectiveness by examining whether objectives have been achieved, whether new technological risks have emerged, whether the regulation creates unintended consequences, and whether the burden remains proportionate. Evaluation is particularly important in the context of Industry 4.0 because a regulation that is appropriate under one technological condition may become less effective as technology evolves⁸⁸.

⁸⁶ Johnson, "Caught in Quicksand?" 709–725

⁸⁷ Sergio Urueña, "Responsibility through Anticipation? The 'Future Talk' and the Quest for Plausibility in the Governance of Emerging Technologies," *NanoEthics* 15 (2021): 271–302, DOI 10.1007/s11569-021-00408-5.

⁸⁸ Jacob A. Hasselbalch, "Innovation Assessment: Governing through Periods of Disruptive Technological Change," *Journal of European Public Policy* 25, no. 12 (2018): 1855–1873, DOI 10.1080/13501763.2017.1363805

Evaluation results should then generate institutional learning. Regulatory institutions must learn from empirical experience, technological developments, judicial interpretation, stakeholder feedback, and regulatory outcomes. Learning transforms regulation from a static legal product into an evolving institutional process. In this context, the quality of legislative governance is determined not only by the quality of the initial regulation but also by the ability of institutions to learn from the consequences of that regulation⁸⁹.

Institutional learning then underpins regulatory adjustment. When evaluation shows that an existing regulatory framework is no longer adequate, appropriate adjustments can be made through legally legitimate mechanisms. Adjustment may involve changes to implementing regulations, technical standards, regulatory guidance, institutional arrangements, or, where necessary, legislative amendments. The important point is that regulatory adjustment should be based on evidence and institutional learning rather than merely on political reaction or technological pressure.

The process subsequently returns to the stage of technological anticipation. New technological developments generate new information and regulatory questions, requiring renewed assessment and institutional response. The legislative system therefore operates as a continuous cycle rather than as a one-directional process. This cyclical character represents one of the fundamental differences between conventional legislative design and the Technology-Responsive Regulatory Framework proposed in this study.

Under the conventional model, legislative governance generally follows a linear sequence in which a legal or social problem is identified, a draft is prepared, the draft is discussed, legislation is enacted, and the resulting law is implemented. Although this model remains essential for maintaining legality and democratic legitimacy, it tends to conceptualize enactment as the culmination of the legislative process. Once legislation

⁸⁹ Deirdre Ahern, “The New Anticipatory Governance Culture for Innovation: Regulatory Foresight, Regulatory Experimentation and Regulatory Learning,” *European Business Organization Law Review* 26 (2025): 241–283, DOI 10.1007/s40804-025-00348-7

has been enacted, subsequent changes often depend upon the emergence of another significant legal or political impetus.

The Technology-Responsive Regulatory Framework introduces a different understanding. Legislation remains subject to the conventional requirements of planning, drafting, deliberation, enactment, and promulgation, but these stages are embedded within a broader continuous governance cycle. Anticipation informs assessment; assessment informs participation and regulatory design; implementation generates empirical experience; evaluation produces institutional learning; and learning creates the basis for regulatory adjustment and renewed anticipation.

The theoretical significance of this transformation lies in the complementary relationship between the three theories employed in this study. Responsive Law explains why the legislative system must remain connected to changing social and technological realities. Law cannot function effectively if it becomes detached from the environment it seeks to regulate. Responsiveness therefore requires legislative institutions to continuously listen to social developments and incorporate relevant technological realities into legal decision-making.

Adaptive Governance, in turn, explains how the regulatory system should respond to uncertainty and complexity. Because technological developments cannot always be predicted accurately, regulation must learn from implementation and adjust accordingly. Adaptation therefore requires institutional flexibility, coordination, knowledge sharing, monitoring, evaluation, and the capacity to modify regulatory responses in response to new evidence.

Meanwhile, Anticipatory Governance provides the forward-looking dimension. It requires legislative institutions to consider technological developments and potential risks before they become fully established. Through foresight, horizon scanning, technology assessment, and early stakeholder engagement, the legal system can move from merely reacting to existing problems toward preparing for possible future challenges⁹⁰.

Integrating these three perspectives fundamentally transforms the meaning of legislative responsiveness. Responsive Law provides the

⁹⁰ Fahy, "Regulator Reputation and Stakeholder Participation," 138–157

normative orientation, Anticipatory Governance provides the future-oriented perspective, and Adaptive Governance provides the institutional capacity for continuous learning and adjustment. Together, they enable the legislative system to respond to technological change without sacrificing legal certainty, democratic legitimacy, accountability, and fundamental rights.

Therefore, the Technology-Responsive Regulatory Framework should not be understood simply as a mechanism for producing legislation more rapidly. Its principal objective is to create a legislative system that is capable of continuously understanding technological change, anticipating potential consequences, incorporating interdisciplinary knowledge, engaging affected stakeholders, assessing regulatory alternatives, learning from implementation, and adjusting legal responses when necessary.

This represents a shift from a linear legislative paradigm to a cyclical, learning-oriented one. The transformation is therefore not from regulation to deregulation, nor from law to technology, but from static law-making toward continuously responsive governance. The legislative process remains legally structured, but its institutional capacity becomes more dynamic and better able to respond to uncertainty.

The proposed framework consequently establishes a new relationship between technology, knowledge, legislation, implementation, and institutional learning. Technology generates change; technological anticipation identifies possible future developments; interdisciplinary knowledge and participation provide the information necessary for assessment; evidence informs legislative decisions; regulation establishes legally legitimate responses; implementation generates experience; evaluation produces knowledge; and institutional learning enables regulatory adjustment. The process then continues as technological conditions evolve.

In this sense, the framework's principal contribution is to reconceptualize legislative design as an adaptive governance process. The object of reform is not merely the content of individual technology regulations, but the legislative system's institutional capacity to remain relevant amid continuous technological transformation.

Thus, the Technology-Responsive Regulatory Framework offers Indonesia a basis to move from reactive regulation to anticipatory

regulation, from static rules to adaptive regulation, from sectoral decision-making to coordinated governance, from limited expertise to interdisciplinary knowledge, and from one-time legislative enactment to continuous regulatory learning. This transformation provides a stronger foundation for ensuring that Indonesian law can govern technological innovation while protecting public interests, fundamental rights, democratic values, and the rule of law.

From the perspective of Responsive Law, the framework ensures that legislation remains connected to social and technological realities. Law is not treated as an autonomous system isolated from technological transformation but as an institutional instrument that must respond to changing conditions while maintaining normative legitimacy. Responsiveness is therefore reflected in legislative institutions' capacity to listen to society, incorporate relevant knowledge, and adjust legal responses to emerging needs.

From an Adaptive Governance perspective, the framework builds the institutional capacity needed to manage complexity and uncertainty. Coordination among ministries and agencies, interdisciplinary expertise, stakeholder networks, monitoring, evaluation, and regulatory adjustment enable the legal system to learn from experience. Adaptability is thus not equivalent to regulatory flexibility without limits; it is structured flexibility operating within principles of legality, accountability, transparency, and institutional responsibility.

From an Anticipatory Governance perspective, the framework shifts legislative policy from retrospective problem-solving to prospective risk management. Foresight and technology assessment allow policymakers to consider possible futures before technological developments become irreversible or systemic. The regulatory system therefore gains the capacity to intervene earlier while avoiding premature regulation based on unsupported assumptions.

Integrating these three theoretical perspectives creates an important balancing function. Responsive Law protects social relevance; Adaptive Governance protects institutional learning and flexibility; Anticipatory Governance protects future-oriented risk management. Together, they must operate within the broader principles of legal certainty, democratic legitimacy, accountability, justice, innovation, and protection of fundamental rights.

This balancing function is particularly important for Indonesia. The country's digital transformation creates strong incentives for technological innovation and economic development, while the same transformation generates risks involving privacy, cybersecurity, discrimination, misinformation, consumer protection, employment, and accountability. The regulatory system must therefore avoid two opposite extremes: regulatory rigidity that inhibits innovation and regulatory permissiveness that fails to protect society.

The proposed framework seeks to occupy the space between these extremes. It does not advocate deregulation, nor does it advocate comprehensive regulation of every technological development. Instead, it promotes proportionate, evidence-based, risk-sensitive, and continuously evaluated regulation. The appropriate regulatory response should depend on the technology's characteristics and potential consequences.

For this reason, a Technology-Responsive Regulatory Framework should also adopt a risk-based regulatory orientation. Technologies presenting limited risks may be governed primarily through principles, standards, transparency requirements, and voluntary or co-regulatory mechanisms. Technologies presenting significant risks may require stronger oversight, mandatory safeguards, auditing, human supervision, accountability mechanisms, or sector-specific requirements. Technologies capable of producing severe and irreversible harm may require more restrictive intervention.

Such differentiation is essential because Industry 4.0 technologies are not homogeneous. A uniform regulatory model may either overregulate low-risk innovation or underregulate high-risk applications. A technology-responsive system should therefore match the intensity of regulatory intervention with the nature, scale, probability, and potential consequences of the risks involved.

The framework also has implications for Indonesia's institutional architecture for lawmaking. The transformation cannot be achieved solely through changes to legislative drafting techniques. It requires institutional mechanisms that enable continuous interaction between legislative bodies, executive institutions, regulators, scientific communities, technology industries, and society. This includes strengthening technological expertise within policy-making institutions,

developing mechanisms for inter-agency regulatory coordination, establishing systematic technology assessment, improving regulatory impact analysis, and institutionalizing post-enactment review.

Consequently, the proposed framework introduces a different understanding of legislative competence. Legislative competence in the Industry 4.0 era should no longer be measured solely by the ability to draft legally coherent texts. It should also include the capacity to understand technological change, evaluate evidence, anticipate risks, engage stakeholders, coordinate institutions, monitor implementation, and revise regulatory responses when circumstances change.

This proposition constitutes the principal novelty of the study. Existing approaches to technology governance frequently focus on the substantive regulation of particular technologies. The framework developed in this research shifts the analytical focus from “how technology should be regulated” to “how the legislative system itself should be designed to remain responsive to technological transformation.” The novelty therefore lies in treating legislative design as an object of technological adaptation⁹¹.

In this respect, the Technology-Responsive Regulatory Framework can be understood as a meta-regulatory framework. It does not prescribe a single substantive rule for artificial intelligence, blockchain, robotics, or other emerging technologies. Instead, it establishes the institutional and procedural conditions through which appropriate substantive regulation can be continuously developed. Its primary concern is therefore the regulatory system’s capacity to remain legitimate, informed, adaptive, and future-oriented amid technological uncertainty⁹².

⁹¹ Brass and Sowell, “Adaptive Governance for the Internet of Things,” 1092–1110.

⁹² Matti Rantala, “The Logic of Regulatory Impact Assessment: From Evidence to Evidential Reasoning,” *Regulation & Governance* (2024), DOI 10.1111/rego.12542.

Conclusion

Industry 4.0 has fundamentally transformed the context in which Indonesia designs and implements legislation. The rapid development of artificial intelligence, big data, the Internet of Things, blockchain, robotics, and other emerging technologies has generated regulatory challenges characterized by speed, complexity, uncertainty, and cross-sectoral effects. The analysis demonstrates that these characteristics expose significant limitations in conventional legislative design, particularly its predominantly reactive orientation, sectoral institutional structure, limited integration of technological expertise, and insufficient mechanisms for continuous regulatory evaluation. The central problem is therefore not merely the absence of technology-specific legislation, but the legislative system's limited capacity to respond to technological transformation.

The study finds that Indonesia needs to transition from conventional legislative governance to a technology-responsive legislative model that is responsive, adaptive, and anticipatory. Responsive Law provides the normative foundation by requiring legislation to remain connected to changing social realities, public interests, justice, and rights protection. Adaptive Governance contributes the institutional capacity for learning, coordination, experimentation, monitoring, and regulatory adjustment under conditions of complexity and uncertainty. Anticipatory Governance adds a forward-looking dimension by requiring legislative institutions to identify emerging technological trajectories, assess potential risks, and consider possible social consequences before they become entrenched. Integrating these three perspectives constitutes the principal theoretical contribution of this study.

The analysis further demonstrates that adaptive and anticipatory legislative governance should not be understood simply as an acceleration of law-making. Regulatory speed without institutional learning, technological assessment, and accountability may merely reproduce regulatory deficiencies more quickly. What is required is a transformation of the legislative process from a linear model of problem–legislation–implementation toward a continuous governance cycle of

technological monitoring, foresight, risk assessment, regulatory design, stakeholder engagement, implementation, evaluation, institutional learning, and regulatory adjustment. This model recognizes that, in the context of Industry 4.0, legislation cannot always be treated as a final, permanent legal product.

The study identifies six institutional capacities that are essential to this transformation: (1) technological foresight and horizon scanning; (2) interdisciplinary technological expertise; (3) meaningful stakeholder participation; (4) evidence-based and impact-oriented law-making; (5) adaptive and coordinated regulatory mechanisms; and (6) continuous post-enactment evaluation. These capacities provide the institutional infrastructure legislative systems need to respond not only to technologies that have already generated legal problems but also to emerging technological developments whose consequences remain uncertain.

The Indonesian experience shows that elements of this transformation have already emerged, particularly through cross-ministerial coordination in AI governance, public consultation, regulatory harmonization, and the gradual development of a national artificial intelligence framework. Nevertheless, these initiatives remain fragmented and have not yet been fully institutionalized as a coherent legislative architecture. Indonesia's principal challenge is therefore to transform individual regulatory initiatives into a systematic and permanent framework for technology-responsive legislative governance.

Accordingly, this study proposes that the Technology-Responsive Regulatory Framework should be understood as an institutional and procedural architecture rather than as a single substantive law governing a particular technology. Its purpose is to ensure that the legislative system can anticipate technological change, integrate diverse forms of knowledge, involve affected stakeholders, generate regulatory evidence, experiment where appropriate, evaluate regulatory consequences, and revise legal responses as technological and social conditions change. This framework seeks to reconcile two objectives that are often treated as contradictory: regulatory adaptability and legal certainty. Adaptability should operate through structured institutional procedures rather than through unrestricted discretion, while legal certainty should not become an obstacle to necessary regulatory learning and adjustment.

The principal contribution of this study therefore lies in shifting the analytical focus from regulating technology to redesigning the legislative system so that it can continuously respond to technology. This represents a conceptual shift from technology-specific regulation toward technology-responsive legislative design. This shift matters for Indonesia, where the growing integration of digital technologies across economic, social, and governmental sectors makes fragmented, purely reactive regulation increasingly inadequate.

Ultimately, the transition toward technology-responsive legislative governance requires Indonesia to reconceptualize legislation not as a static legal endpoint but as a continuous process of anticipation, responsiveness, adaptation, and institutional learning. The objective is not to predict technological change with certainty, which is neither possible nor necessary, but to construct legislative institutions capable of recognizing emerging signals, assessing risks and opportunities, engaging relevant stakeholders, incorporating evidence, evaluating implementation, and adjusting regulatory instruments while preserving legality, accountability, democratic legitimacy, and the protection of fundamental rights. In this sense, a technology-responsive legislative system offers a more sustainable foundation for governing Industry 4.0 and for ensuring that technological innovation develops within a legal order capable of remaining both adaptive to change and committed to the rule of law.

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