

Research on the Driving Factors and Mechanism of Intelligent Transformation of Marine Ranches

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Abstract

Against the backdrop of the superimposed advancement of the digital economy and the maritime power strategy, Marine ranches are gradually shifting from traditional resource conservation and restocking platforms to intelligent production and governance systems characterized by data-driven, algorithmic decision-making, equipment collaboration, and platform governance. Compared with general manufacturing or platform enterprises, Marine ranches have triple attributes of natural ecosystem, offshore engineering system and industrial operation system. Their transformation involves not only the introduction of digital technologies such as sensing and perception, communication networks, intelligent equipment, cloud platforms and artificial intelligence, the transformation is also influenced by multiple factors such as the complexity of the Marine environment, differences in resource endowments, the intensity of institutional regulation, market traceability requirements, and ecological governance goals. Although existing research has accumulated relatively rich results from the perspectives of digital transformation, smart fisheries, information system adoption, dynamic capabilities, and ecological governance, there is still a lack of a unified explanation for "why it occurs, who drives it, through what paths it deepens, and how it forms stable changes at the organizational level." Especially under the dual constraints of the blue economy and ecological civilization, how digital technology can be transformed from instrumental input to structural change force still requires a more systematic theoretical review.

Based on this, this paper conducts a theoretical study on the driving factors and mechanisms of the intelligent transformation of Marine ranches, with the aim of constructing an analytical framework that can connect antecedent conditions, process deepening, capability embedding and result orientation. First, on the basis of the technology-organization-environment framework, the article identifies eight key drivers: technological advantage, technological maturity, enterprise strategy, resource endowment, ecological orientation, institutional pressure, competitive pressure and market demand; Then, in combination with the theory of information technology assimilation, absorption capacity and institutionalization, the intelligent transformation of Marine ranches is understood as a progressive process of digital technology adoption, digital technology absorption and digital technology institutionalization; Further illustrate how enterprise capabilities play an amplifying, transforming and stabilizing role in this process from the perspectives of resource-based view, dynamic capabilities and digital innovation. Based on this, this paper presents the overall logic of "antecedent-driven - transformation-motivated - technological progression - capability amplification - performance release" and forms several research propositions to explain the formation mechanism, deepening mechanism and value generation mechanism of the intelligent transformation of Marine ranches.

This paper argues that the intelligent transformation of Marine ranches is not a simple equipment update or single-point technological upgrade, but a systematic change that is shaped by both internal and external driving factors, deepened by organizational learning and process reengineering, and ultimately achieves sustained value release through institutional embedding. Technological factors determine the feasibility and tool boundaries of the transformation, organizational factors determine the resource base and strategic direction of the transformation, environmental factors determine the external pressure and opportunity window of the transformation, and dynamic capabilities, absorptive capabilities and innovative capabilities determine whether digital technology can truly be transformed into organizational practices and competitive advantages. The theoretical contribution of this paper lies in expanding the interpretive boundaries of the TOE framework in the context of Marine ranches; Introducing the process logic of "adoption - absorption - institutionalization" into the study of the intelligent transformation of Marine ranches; and construct a model of the mechanism that takes into account ecological,

economic and social goals. The findings will help deepen research on the digital transformation of Marine ranches and provide theoretical support for the construction of smart fisheries, the governance of Marine data, and the phased advancement of intelligent transformation by enterprises.

Keywords

Digital technology; Marine ranches; Intelligent transformation; Drivers; Mechanism of action; Institutionalization of technology

1. Introduction

In recent years, the reshaping effect of digital technology on traditional industrial organization and value creation models has become increasingly prominent. The new generation of digital technologies, represented by the Internet of Things, artificial intelligence, big data, edge computing, remote sensing monitoring, digital twins and blockchain, have not only changed the way enterprises obtain information, allocate resources and coordinate activities, but also promoted more real-time, networked and intelligent operating mechanisms in agriculture, manufacturing, logistics and public governance. Compared with land-based industries, the production objects of Marine ranches are more ecologically sensitive, the production scenarios are more spatially dispersed, and the production decisions rely more on real-time monitoring and empirical judgment, which makes them naturally suitable for state perception, remote control, risk early warning, quality traceability and collaborative governance through digital technology. The empowerment of Marine ranches by digital technology is not a peripheral incremental transformation, but a deep transformation related to the reconstruction of production functions, governance structures and value logics.

However, in reality, the intelligent transformation of Marine ranches has not occurred naturally. A considerable number of entities have introduced sensors, automatic feeding equipment, underwater cameras and e-commerce traceability systems, but still face the predicament of "equipment online but data not used, platforms built but processes not changed, systems deployed but regulations not embedded". That is to say, the entry of digital technology into an organization does not equal the completion of the intelligent transformation, and there is a clear "conversion gap" between technology investment and value realization. Some entities fail to achieve sustained performance after the initial investment, and the root cause lies in the fact that the technology has not been localized, organization-learned, process-reengineered, and institution-embedded. The intelligent transformation of Marine ranches must therefore be understood as a multi-stage, context-strong, capability-heavy system process, rather than a one-off technology purchase.

The existing research provides inspiration for this

paper in three aspects. First, research on information systems and organizational innovation shows that the diffusion of new technologies usually does not stop at initial adoption but goes through a progressive process from adoption to popularization and from use to embedding. Second, digital transformation research indicates that the digital transformation of enterprises is influenced by a combination of technological conditions, organizational resources, external environment and management cognition, and the effects of different factors often vary at different stages. Third, smart fisheries and smart aquaculture research has demonstrated the broad prospects of the Internet of Things, 5G, machine vision and artificial intelligence in fish behavior recognition, water quality monitoring, precise feeding and risk warning, but there is still insufficient explanation of how these technologies can bring about organizational change and sustained advantages at the Marine ranch level. The review of smart fish farms by Wang et al. (2021) shows that modern aquaculture is forming integrated systems based on perception, computing and automatic control, but theoretical integration is still needed to move from technology application to organizational transformation.

Based on this, this paper focuses on the core issue of "the driving factors and mechanisms of intelligent transformation of Marine farms" and attempts to answer four interrelated sub-questions: The first question is why there is a need for intelligent transformation in Marine ranches. The second question is what key factors are driving this transformation. The third question is how these factors are transformed into continuous change through organizational processes. The fourth question is what role does enterprise capability play in it. In response to these questions, this paper uses theoretical integration and conceptual modeling to construct an overall analytical framework that can explain "antecedent - process - capability - outcome" in the context of Marine ranches, and based on this, puts forward verifiable research propositions.

2. Literature Review and Question Raising

Research on the intelligent transformation of Marine pastures is currently mainly distributed across three knowledge lineages. The first category of research focuses on smart fisheries, smart aquaculture and Marine informatization, focusing on how technical

solutions such as sensor monitoring, automatic feeding, machine vision, edge computing, unmanned equipment and digital platforms are applied to the aquaculture production process. This type of research is important for depicting the application scenarios of the technology, identifying key equipment and demonstrating the application prospects, but it is more about "what the technology can do" and less about "why organizations adopt it, how to deepen it and how to form a stable mechanism". The second type of research comes from the field of enterprise digital transformation and information system implementation, emphasizing the impact of technology adoption, organizational support, data capabilities and business reconfiguration on performance. The theoretical accumulation is relatively mature, but the research subjects are mostly manufacturing, retail or platform enterprises, and the applicability to ecological-engineering-industry complex systems such as Marine ranches still needs contextualized interpretation. The third type of research comes from the field of ecological governance and sustainable transformation, focusing on the role of digital technology in natural resource monitoring, ecological governance and multi-synergy, emphasizing the impact of digitalization on environmental governance capacity and public value creation, which provides important inspiration for understanding the characteristics of Marine ranches that have economic, social and ecological goals.

From a general perspective of digital transformation theory, Vial summarizes digital transformation as systemic changes in organizational strategy, structure, processes, and value creation logic triggered by digital technology, emphasizing that the impact of technology is not limited to tool substitution but leads to reshaping of organizational identity, resource allocation, and business models. Verhoef et al. further pointed out that digital transformation requires a comprehensive understanding from multiple perspectives such as the customer interface, operational processes, organizational structure and ecosystem relationships, and studies at a single department or single technical level often struggle to grasp its overall nature. Hanelt et al.'s systematic review shows that although research on digital transformation is growing rapidly, it is still theoretically fragmented, especially lacking a comprehensive explanation of the boundary conditions and process mechanisms of organizational change. The study suggests that to explain the intelligent transformation of Marine ranches, technical conditions, organizational conditions, environmental conditions and stage processes must be incorporated into the same analytical framework. (cite turn0search4 turn2search0 turn12search0)

From the perspective of technology implementation and assimilation research, organizations often go

through subsequent stages such as absorption, popularization, normalization, and deep embedding after adopting complex information technologies. Purvis et al.'s research on knowledge platform assimilation shows that complex technologies only truly unlock value when they are embedded in everyday workflows. In their research on the diffusion of e-commerce in multinational enterprises, Zhu et al. suggest that technology diffusion is not a single-point decision but a phased assimilation process driven by the combined effects of technology, organization and environmental factors. Meanwhile, the absorptive capacity theory suggests that the key to an organization's utilization of external knowledge lies not in "how much knowledge is accessed", but in its ability to identify its value, complete digestion and absorption, and further transform it into internal capabilities. From this, it can be seen that the intelligent transformation of Marine ranches cannot be measured merely by "whether technical equipment is purchased", but should focus on the continuous evolution from adoption to absorption and then to institutionalization. (cite turn8search1 turn1search2 turn0search6)

Nevertheless, there are three shortcomings in the existing research. First, most studies equate the application of digital technology in Marine ranches with intelligent transformation, ignoring the process of adaptation, integration and institutional embedding that technology still needs to go through after entering the organization. Second, discussions on drivers tend to focus either on technological attributes or policy push, and less on comparing the roles of technological advantages, organizational strategies, resource endowments, ecological orientation, competition and market demand within the same framework. Third, the particularity of Marine ranches determines that their transformation goals are not only to increase production and efficiency, but also to enhance ecological governance capacity, public service capacity and brand trust capacity, but the existing literature has insufficient evidence of the relationship between these multi-dimensional goals and driving mechanisms. It is precisely in these blanks that this paper aims to establish a more systematic explanatory logic.

It should also be noted that the intelligent transformation of Marine ranches has obvious spatial externalities and governance externalities. On the one hand, Marine environmental information, disaster warnings, logistics tracking and ecological monitoring are often not something that a single enterprise can fully control independently, and the transformation cannot do without data collaboration among governments, research institutions, platform enterprises and upstream and downstream entities. On the other hand, the transformation effect of Marine ranches should not be measured only by the profits of individual enterprises, but also by their

impact on the quality of the Marine environment, the restoration of fishery resources, consumer trust and regional industrial synergy. For this reason, the intelligent transformation of Marine ranches places more emphasis on public governance attributes and ecological value attributes than the digitalization of general enterprises, which is why it is necessary to incorporate ecological orientation and external environmental factors into the same analytical framework in this paper.

3. Theoretical Basis

The theoretical basis of this paper is mainly composed of three parts: first, the technology-organization-environment framework; second, the theory of technology assimilation and absorption capacity; third, the resource-based view and the theory of dynamic capacity. The three are respectively used to explain the "anprocausal sources", "process deepening" and "capacity amplification" of the intelligent transformation of Marine ranches, and together they support the construction of the overall analytical framework.

First, the TOE framework emphasizes that technological innovation behavior at the organizational level is not solely determined by the quality of technology, but is jointly shaped by the technological environment, organizational environment, and external environment. The technical environment answers "whether the technology is worth using and can be used"; The organizational environment answers whether the organization wants to transform and whether it has the ability to transform; The external environment answers whether it is pushing or forcing the organization to transform. This framework fits closely with the reality of the intelligent transformation of Marine ranches. Marine ranches have to deal with technical issues such as water quality monitoring, disease early warning, feeding optimization and equipment coordination, as well as corporate strategic investment, resource base, personnel skills and ecological responsibility, and adapt to external changes such as policy regulation, market traceability, industry competition and platform coordination. Therefore, TOE provides a structured classification basis for identifying drivers.

Second, the theory of technology assimilation and absorption helps explain why digital technologies are often "easy to deploy but hard to achieve". Cohen and Levinthal suggest that the key to an organization's utilization of external knowledge lies in its absorptive capacity, that is, the ability to identify, digest and apply new knowledge. Since then, related research has gradually understood technology absorption as a process from surface use to deep integration. Purvis et al. and Zhu et al. further demonstrated that

complex technologies must go through organizational learning, process integration, cross-departmental coordination, and everyday use before they can shift from "being adopted" to "being assimilated". In the context of Marine ranches, this means that systems such as sensors, underwater video, unmanned vessel inspection, intelligent feeding or traceability platforms will only truly function after they are stably coupled with aquaculture processes, risk control, operational decision-making and performance evaluation mechanisms.

Third, the resource-based view and the dynamic capability theory provide a key perspective for explaining the differences in transformation among enterprises. Bharadwaj's research on IT capabilities suggests that information technology can only become a source of sustained competitive advantage when combined with human resources, organizational processes, and intangible assets. Teece et al. stress that dynamic capabilities are essentially an organization's ability to perceive opportunities, seize them, and continuously restructure its resource base. For Marine ranches, even in the face of the same policy environment and technological supply, the digital cognition, resource organization ability, process reengineering ability and innovation ability of different entities can still lead to significant differences. This indicates that for the drivers to translate into actual transformation results, the intervention of capability mechanisms is indispensable. Whether digital technology can transform from a single device into organizational capability depends on whether the enterprise has the ability to continuously restructure resources, coordinate processes and promote institutionalization.

Overall, the TOE framework reveals the sources of drivers, the technology assimilation and absorption capacity theory reveals the stage logic of transformation, and the resource-based and dynamic capacity theory reveals the transformation differences and the sources of their performance. Three types of theories can complement each other in the context of Marine ranches: the former answers "why transform," the middle one answers "how to deepen," and the latter answers "why some subjects can transform, some subjects cannot transform."

4. Identification of the Driving Factors for the intelligent Transformation of Marine ranches

In the context of Marine ranches, the antecedents driving intelligent transformation can be summarized into three dimensions: technology, organization, and environment, and further refined into eight types of factors: technological advantage, technological maturity, enterprise strategy, resource endowment, ecological orientation, institutional pressure,

competitive pressure, and market demand. Such a division is both theoretically clear and can well cover the key conditions that affect the transformation of Marine ranches in reality.

4.1 Technical factors.

Technical superiority refers to the relative superiority of digital technology over traditional management methods in terms of efficiency improvement, cost control, risk identification, quality traceability, and decision optimization. For Marine ranches, if digital perception, automatic control and data analysis can significantly reduce the cost of manual inspection, improve feed conversion efficiency, and enhance disease prevention and control as well as aquaculture environment management, then enterprises are more likely to develop the willingness to transform. Technology maturity is reflected in the stability, replicability, compatibility and operational availability of the technology. If the technology is still in the experimental stage, the standards are not uniform, the maintenance costs are high, or the maritime adaptability is poor, enterprises may wait and see even if they recognize its potential value. In theory, technological superiority mainly affects whether one wants to use it or not, and technological maturity mainly affects whether one dares to use it or not.

4.2 Organizational factors.

Corporate strategy is the directional driver of the intelligent transformation. The transformation will receive sustained resource input and cross-departmental collaboration only when management

views digitalization and intelligence as important strategies for reshaping competitiveness and enhancing governance capabilities, rather than accessory projects. Resource endowments are the material and organizational basis of transformation, including hard resources such as money, equipment, talent, data, and networks, as well as soft resources such as management experience, collaborative relationships, and brand reputation. The more abundant the resources, the more capable the enterprise is of bearing the upfront trial-and-error costs and completing the subsequent integration. Ecological orientation is an important organizational orientation that distinguishes Marine ranches from general commercial entities. It is not only reflected in the recognition of the value of environmental protection, ecological restoration and sustainable use, but also in the integration of ecological goals into production monitoring, standard management and business evaluation. The stronger the ecological orientation, the more inclined enterprises are to use digital means to enhance environmental perception, risk warning and resource protection capabilities.

4.3 Environmental factors.

Institutional pressure mainly comes from external institutional requirements such as government regulation, industry norms, environmental assessment, quality and safety, data reporting and policy orientation. For highly regulated areas such as Marine ranches, institutional pressure can influence the pace of corporate transformation through compliance requirements and incentive policies. Competitive

Dimensions	Factors	Core content	Main function
Technology	Technical advantage	The relative benefits of digital technology over traditional methods in terms of efficiency, cost, monitoring and decision-making	Enhance perception of the necessity of transformation
Technology	Technology maturity	Technical stability, compatibility, maritime suitability and operational availability	Reduce adoption risk and enhance implementability
Organization	Corporate Strategy	Management's awareness, commitment, and strategic embedding of intelligent transformation	Provide direction guidance and resource allocation
Organization	Resource endowment	Basic conditions such as capital, equipment, talent, data, network and management experience	Support trial and error, integration and diffusion
Organization	Ecological-oriented	Incorporate environmental protection, resource restoration, and sustainable governance into business objectives	Strengthen the need for ecological transformation
Environment	Institutional pressure	Institutional constraints such as policy norms, regulatory requirements, quality and safety, and data reporting	Form compliance-driven
Environment	Competitive pressure	Peer comparison, brand competition, efficiency competition and channel competition pressure	Forming efficiency-driven
Environment	Market demand	Consumer demand for traceability, quality, experience, and customized services is escalating	Creating value drivers

Table 1 Core Drivers of the intelligent Transformation of Marine ranches and their theoretical implications

pressure reflects the external challenges that companies face in comparison with peers, product differentiation, brand building, and channel contention. When competition intensifies, companies are more likely to enhance efficiency, build brands and strengthen services through digital technologies. Market demand is one of the most direct external drivers of the intelligent transformation, especially as evidenced by the growing demand from consumers for quality traceability, fresh logistics, customized services, eco-certification, and integrated cultural and tourism experiences. The more the market emphasizes transparency, standardization and personalization, the more Marine ranches need to rely on digital technology to reshape the supply system.

It should be particularly noted that these eight factors are not isolated from each other but have a significant complementary and coupled relationship. For example, technological advantages are more likely to translate into transformational actions only when the corporate strategy is clear and resources are abundant; institutional pressure, lacking market demand and competition-driven forces, often leads to passive compliance; ecology-oriented governance is difficult to translate into monitorable, assessable and sustainably optimized governance without digital technology support. Therefore, the key to identifying the drivers is not simply listing the variables, but revealing the relationships and chains of influence among them.

5. The mechanism of action of drivers

Drivers do not automatically generate the outcome of the intelligent transformation; they need to go through a series of intermediary links to be transformed into actual changes at the organizational level. In light of the production and governance characteristics of Marine ranches, this paper argues that the transformation is mainly manifested as a progressive chain of "drivers activating transformation motivation - transformation motivation initiating technology adoption - technology adoption promoting technology absorption - technology absorption facilitating technology institutionalization - institutionalization bringing stable performance". This chain reflects both the logical continuity from cause to effect and the phased characteristics of the intelligent transformation of Marine ranches.

First, the drivers play a first-round role by shaping the transformational motivation. Transformational motivation is not an abstract will in the psychological sense, but a comprehensive judgment at the organizational level regarding the necessity, feasibility, and strategic significance of digital technologies. When enterprises see the relative advantages of digital technology, have basic resource support, and are simultaneously stimulated by the external market and competition, it is easier for management to form a stronger perception of transformation and

incorporate intelligent transformation into the strategic agenda. Conversely, if the technology is advanced but the resources are insufficient, the market demand is ambiguous, or the strategic support is weak, the organization may remain in a wait-and-see state for a long time. In other words, the drivers first affect "whether it's on the transition track".

Second, transformational motivation initiates technology adoption through resource allocation and decision commitment. The core of the technology adoption phase is to get the technology "into the organization," including completing equipment procurement, system launch, pilot deployment, and initial operation. In the context of Marine ranches, this typically involves the introduction of water quality monitoring equipment, intelligent feeding systems, underwater visual recognition, traceability platforms, and unmanned inspection equipment. At this point, although the organization has taken transformation actions, the technology still remains more at the point application and instrumental level. Without subsequent organizational learning and process reengineering, the adoption stage is prone to the shallow digitalization phenomenon of "new systems serving old processes".

Third, technology adoption must go through technology absorption in order to bring about a substantial transformation. Technology absorption emphasizes the shift from "usable" to "useful", and its essence is that organizations complete learning, adaptation, recombination and integration in the process of using. The complex Marine environment of Marine ranches determines that many digital technologies cannot be directly applied to the scenarios, but must go through local debugging, parameter optimization, data cleaning, cross-system connection and job collaboration. For example, the linkage of underwater cameras with feeding control, the coupling of environmental monitoring with disease early warning models, and the data integration of traceability platforms with sales systems are all typical technology absorption activities. Only when the technology is truly embedded in the operation process and decision-making mechanism will the organization shift from "having the technology" to "mastering the technology".

Fourth, the absorption of technology further promotes the institutionalization of technology. Institutionalization is not just about keeping the system for the long term, but about elevating digital technology as part of organizational rules, management practices, performance standards, and collaborative governance logic. For Marine ranches, digital technology is truly transformed from an "exogenous tool" to an "endogenous system" only when core activities such as inspection, feeding, early warning, aquaculture records, traceability management, environmental assessment and business decision-making are all based on data rules and platform synergy. A notable feature of

this stage is that technology is no longer dependent on a few capable people or short-term projects, but becomes a stable foundation for the organization's operation.

Fifth, institutionalization is a prerequisite for the stable release of performance. The performance of Marine ranches has three attributes: economic, social and ecological. The economic aspect shows efficiency improvement, cost reduction, stable output and brand premium; At the social level, it shows enhanced food safety, quality traceability, consumer trust and industrial synergy; The ecological level is characterized by enhanced environmental monitoring, forward risk warning, optimized resource utilization and improved ecological restoration capabilities. The direct impact of the technology adoption stage on performance is often limited or even lagging, while the absorption and institutionalization stage can better explain the formation of sustained performance. That is to say, the performance of the intelligent transformation of Marine ranches is not "fabricated", but "embedded".

The capability mechanism has always played a key role in the above chain. Dynamic capabilities enable enterprises to identify technological opportunities and strategic Windows in the face of environmental changes; resource orchestration capabilities help enterprises reorganize scattered equipment, data, personnel and processes; and innovation capabilities drive organizations to continuously improve business models and governance patterns. It is these capabilities that make the same drivers produce different results in different entities: some quickly complete pilot diffusion and institutional embedding, while others remain at the surface application and project-based construction stage.

6. Theoretical Analysis framework and research proposition

Based on the previous theoretical integration, this paper constructs an overall analysis framework for the intelligent transformation of Marine ranches: starting from antecedent-driven, with transformational motivation as the trigger mechanism, with digital technology adoption, digital technology absorption and digital technology institutionalization as the process chain, with dynamic capacity, absorption capacity and innovation capacity as the amplification mechanism, and with economic, social and ecological performance as the result orientation. The core idea of the framework is that the intelligent transformation of Marine ranches is not a one-way technological diffusion, but a systematic change that is driven by multiple factors working together, continuously deepened through organizational processes, and ultimately forms institutionalized capabilities and multi-dimensional performance.

Based on this framework, the following research

propositions are proposed in this paper. Proposition 1: The more obvious the technological advantages are, the easier it is for the main body of Marine ranches to develop the motivation for intelligent transformation. Proposition 2: The higher the technological maturity, the more likely the Marine ranching entity is to translate the transformation motivation into substantive adoption actions. Proposition 3: The clearer the corporate strategy and the more emphasis it places on digital reconfiguration, the more it can significantly strengthen the motivation for intelligent transformation and drive cross-departmental resources to focus on intelligent transformation. Proposition 4: The more abundant the resource endowment, the better the ocean ranch can afford the cost of trial and error, promote system integration, and thereby increase the probability of technology adoption to technology absorption.

Proposition 5: The stronger the ecological orientation, the more inclined Marine ranches are to use digital technology for environmental monitoring, risk warning, resource conservation and governance transparency, thereby enhancing the long-term stability of technology institutionalization. Proposition 6: Institutional pressure, competitive pressure and market demand together constitute external environmental drivers, among which institutional pressure mainly activates compliance transformation, competitive pressure mainly activates efficiency transformation, and market demand mainly activates value transformation; When the three work together, it is easiest to form a strong motivation for transformation. Proposition 7: Digital technology adoption positively promotes digital technology absorption, but its performance effect is not significant in the initial stage. Proposition 8: Digital technology absorption positively promotes the institutionalization of digital technology and enhances the stability of intelligent transformation through process reengineering and rule embedding.

Proposition 9: Dynamic capabilities, resource orchestration capabilities and innovation capabilities have a significant positive moderating effect on technology absorption and institutionalization. The stronger the capabilities, the easier it is for the driving factors to be transformed into deep-level organizational changes. Proposition 10: Digital technology institutionalization is a key mediating link in the economic, social and ecological integrated performance of the intelligent transformation of Marine ranches. The significance of the proposition is not to simply linearize the transformation, but to provide a conceptual framework that can be further empirically tested, enabling different researchers to conduct more comparable studies around drivers, stage processes, capability conditions, and multi-dimensional performance.

This framework has three expansions compared to

Proposition Number	Proposition Content
P1-P2	Technological advantage enhances transformational motivation, and technological maturity strengthens the transformation of motivation into adoption action.
P3-P4	Corporate strategy provides directional guidance, and resource endowments support adoption for subsequent integration and diffusion.
P5	The ecological orientation strengthens the demand for intelligent transformation in environmental monitoring, risk early warning and green governance.
P6	Institutional pressure, competitive pressure and market demand respectively constitute compliance-driven, efficiency-driven and value-driven, and the synergy is stronger.
P7-P8	Digital technology adoption promotes technology absorption, and technology absorption further promotes technology institutionalization.
P9	Dynamic capabilities, resource orchestration capabilities and innovation capabilities positively regulate the process of technology absorption and institutionalization.
P10	Technology institutionalization is a key mediator for the stable release of economic, social and ecological performance.

Table 2 Research propositions within the framework of theoretical analysis

the existing research. First, it moves the intelligent transformation of Marine ranches from "technology application research" to "organizational change research", emphasizing that the transformation is essentially an evolutionary process driven by the coupling of technology, organization and environment. Second, it incorporates the special target structure of Marine ranches into the analysis, and explicitly incorporates ecological orientation and ecological performance into the logic of drivers and results, distinguishing Marine ranches from general commercial entities. Third, it replaces the single adoption perspective with "adopt - absorb - institutionalize", emphasizing the process and lag of value generation, which helps explain the reality of "input without output" and "system without synergy".

7. Management Implications

Although this paper is based on theoretical analysis, its conclusions still have strong implications for policy design and business practice in Marine ranches. For the government, promoting the intelligent transformation of Marine ranches should not be limited to equipment subsidies or platform construction. Instead, the policy focus should be gradually shifted from "promoting adoption" to "promoting absorption and institutionalization". This means that public policy should not only support infrastructure construction and key equipment allocation, but also attach importance to standard system construction, data interface standardization, operation and maintenance service supply, talent training and cross-subject collaboration mechanism. Only by forming a policy chain covering "introduction - integration - embedding"

can digital technology shift from project construction to institutional capacity building.

For enterprises, the intelligent transformation is primarily a strategic issue, and only secondarily technical one. Enterprises need to integrate digital technology with business models, risk control, brand building and ecological governance goals, and avoid understanding intelligence as isolated technology procurement. Especially in the Marine ranch scenario, management should attach importance to early data governance, equipment compatibility assessment, process reengineering and job training, and embed digital capability building into the organization's development plan. For entities with relatively limited resources, it is more appropriate to adopt a phased strategy of "starting with core links, breaking through key scenarios, and gradually expanding platformization" rather than getting stuck in the predicament of high costs and low synergy after a full-scale rollout.

For industry platforms and collaborative entities in the industrial chain, the value of the intelligent transformation of Marine ranches is not only reflected within individual aquaculture units. As functions such as quality traceability, cold chain logistics, Marine tourism and culture, financial services and ecological assessment continue to extend, digital technology will also drive closer data connections between Marine ranches and processing, circulation, regulation and consumption ends. Therefore, industry-level data sharing rules, trusted traceability mechanisms, and cross-agent collaborative platform construction are also indispensable parts of the intelligent transformation. The higher the level of intelligence of a single enterprise, the more it needs to rely on external platforms to achieve mutual recognition of data, co-

creation of value and co-governance of risks.

8. Conclusions and Prospects

This paper constructs a theoretical analysis framework that includes antecedents, processes, capabilities and outcomes, focusing on the driving factors and mechanisms of the intelligent transformation of Marine ranches. The study suggests that the key drivers of the intelligent transformation of Marine ranches come from three dimensions: technology, organization and environment. Among them, technological superiority and technological maturity determine the technical feasibility of the transformation; enterprise strategy, resource endowment and ecological orientation determine the organizational basis and goal orientation of the transformation; institutional pressure, competitive pressure and market demand determine the external stimulus and opportunity window of the transformation. On this basis, the intelligent transformation of Marine ranches is manifested as a progressive process of digital technology adoption, digital technology absorption and digital technology institutionalization, in which dynamic capabilities, resource orchestration capabilities and innovation capabilities play a continuously amplifying and transforming role. What really determines whether the transformation can produce stable performance is not whether the technology enters the organization, but whether the technology can be absorbed and institutionalized.

The core lesson of this article is that the intelligent transformation of Marine ranches should be seen as a systematic reconstruction that combines the attributes of technological evolution, organizational learning and ecological governance. If only equipment investment and system launch are emphasized, it is easy to narrow the intelligent transformation to engineering projects; ignoring environmental constraints and ecological goals underestimates the complexity of digital transformation of Marine ranches compared to general industries. The formation mechanism and deepening logic of the intelligent transformation of Marine ranches can only be better explained by unifying the antecedent-driven, stage-process and capability embedding.

Future research can still be advanced in three areas. First, a questionnaire survey, longitudinal tracking, or configuration analysis could be conducted around the research proposition proposed in this paper to verify the driving structure and stage differences of different types of Marine ranch entities. Second, the impact of regional institutional environment, sea area type, enterprise size and industrial chain location on the intelligent transformation path can be further compared to enhance the contextual explanatory power of the theory. Third, new topics such as trusted data space, platform synergy, digital twin and green

governance can be incorporated into the framework to discuss how Marine ranches can move from "individual intelligentization" to "networked collaborative intelligentization". Through these expansions, research on the intelligent transformation of Marine ranches is expected to move further from conceptual exploration to a more mature theoretical system.

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