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## THE MECHANISM THROUGH WHICH ENTERPRISE DIGITAL TRANSFORMATION INFLUENCES INDUSTRIAL MODERNIZATION: A MANAGEMENT OPTIMIZATION PERSPECTIVE

**Abstract.** This article examines how enterprise digital transformation may influence industrial modernization via management optimization, treating upgrading as a structural manifestation. Using a targeted, non-systematic, mechanism-oriented synthesis of research on digital transformation, organizational capabilities, resource allocation and value-chain upgrading, the study differentiates digital inputs, managerial conversion, firm capabilities and industry-level outcomes. Management optimization comprises process reconfiguration, decision optimization, resource orchestration and organizational coordination. Firm-level capabilities can gain industry-wide significance through diffusion and learning, competitive selection, interfirm resource reallocation and supply-chain/value-chain coordination. The framework specifies digital maturity, managerial capabilities, organizational complementarity, industry conditions and the institutional environment as boundary conditions, while identifying three potential failures in the conversion and aggregation process. Four propositions integrate these relationships into a multi-level explanation and identify pathways for later empirical testing. The contribution lies in connecting the organizational conversion layer to the firm-to-industry transition rather than attributing industrial upgrading directly to technology adoption.

**Keywords:** enterprise digital transformation; management optimization; organizational capabilities; industrial modernization; industrial upgrading; interfirm diffusion; resource reallocation; global value chains.

**Annotatsiya.** Maqolada korxonalarining raqamli transformatsiyasi boshqaruvni optimallashtirish orqali sanoatni modernizatsiya qilishga qanday hissa qo'shishi mumkinligini tushuntiruvchi konseptual model ishlab chiqiladi. Raqamli transformatsiya, tashkiliy qobiliyatlar, resurslarni taqsimlash va qiymat zanjirini takomillashtirish bo'yicha adabiyotlarning maqsadli, tizimli bo'lmagan sintezi qo'llanildi. Modelda raqamli imkoniyatlar, boshqaruvdagi o'zgarishlar, korxona qobiliyatlari va tarmoq natijalari o'zaro farqlanadi. Boshqaruvni optimallashtirish jarayonlarni qayta tuzish, qarorlarni takomillashtirish, resurslarni uyg'unlashtirib boshqarish va tashkiliy muvofiqlashtirishni qamrab oladi. Korxona darajasidagi natijalar bilimlarning tarqalishi, raqobat asosidagi saralash, resurslarning korxonalararo qayta taqsimlanishi hamda ta'minot va qiymat zanjirlari orqali tarmoq darajasiga o'tishi mumkin. Raqamli yetuklik, boshqaruv qobiliyatlari, tashkiliy uyg'unlik, tarmoq va institutsional sharoitlar chegaraviy omillar sifatida ko'rsatiladi. To'rtta nazariy qoida mexanizmning mumkin bo'lgan uzilishlarini va keyingi empirik tekshiruv yo'nalishlarini belgilaydi.

**Kalit so'zlar:** korxonaning raqamli transformatsiyasi; boshqaruvni optimallashtirish; tashkiliy qobiliyatlar; sanoatni modernizatsiya qilish; korxonalararo diffuziya; resurslarni qayta taqsimlash; qiymat zanjiri.

**Аннотация.** Цель статьи - разработать концептуальную модель влияния цифровой трансформации предприятий на модернизацию промышленности через оптимизацию

управления. На основе целевого несистематического синтеза литературы разграничены цифровые ресурсы, управленческое преобразование, способности предприятия и отраслевые результаты. Показано, что реконфигурация процессов, оптимизация решений, оркестрация ресурсов и организационная координация создают предпосылки для повышения производительности, инновационных способностей, человеческого капитала и гибкости организации. Переход к отраслевым результатам возможен через диффузию, конкурентный отбор, перераспределение ресурсов и координацию цепочек стоимости. Выделены граничные условия и возможные разрывы механизма. Теоретический вклад состоит в разграничении внутрифирменного управленческого преобразования и межфирменной агрегации. Четыре теоретических положения задают направления последующей эмпирической проверки.

**Ключевые слова:** цифровая трансформация предприятия; оптимизация управления; организационные способности; модернизация промышленности; межфирменная диффузия; перераспределение ресурсов; цепочки создания стоимости.

JEL Classification: O33; L23; L60

## 1. INTRODUCTION

Enterprise digital transformation changes more than an organization's technological infrastructure. It also reshapes how information enters managerial decisions, how production resources are allocated, and how value is created within and across firms. Prior research places organizational structures and firm capabilities at the center of these changes rather than treating digital tools as self-sufficient determinants of performance [9; 11; 15; 18; 20]. Empirical studies associate digital transformation with technical efficiency, productivity, innovation and resource-allocation outcomes [13; 14; 22], although many of these outcomes are measured primarily at the firm level. A related literature connects digital transformation to participation in global value chains. Feng and colleagues examine the upgrading of manufacturing firms' global value-chain positions [6], while Li associates smart transformation with value-chain upgrading through human resources and total factor productivity [16]. These contributions establish an important connection between digital transformation and upgrading, but they do not, on their own, provide a unified account of the internal managerial conversion process and the subsequent move from improvements in individual firms to changes in an industry. That distinction matters because digital investment need not generate a uniform positive outcome. The effectiveness of process digitalization depends on alignment with operational routines and absorptive capacity [21]. Similarly, improved total factor productivity can coexist with weaker indicators of firm performance [10]. Such findings are difficult to capture with a simple linear narrative in which digitalization automatically produces efficiency and industrial modernization.

This study therefore treats management optimization as an organizational conversion layer between digital possibilities and firm capabilities. Capabilities become relevant to industrial modernization only when they spread, are selected through competition, alter the interfirm allocation of resources, or change relationships within supply and value chains. The research question is: through which managerial and interfirm mechanisms can enterprise digital transformation contribute to industrial upgrading, and under what conditions can firm-level capabilities translate into industry-level outcomes? The study develops an integrated conceptual sequence-digital transformation, management optimization, firm capability development, cross-level aggregation and industrial upgrading-and identifies where the mechanism depends on organizational and industrial conditions. Its contribution is to connect two analytically distinct stages: managerial conversion within firms and aggregation of heterogeneous firm-level changes into industry-level modernization. Four propositions make these links explicit and outline directions for empirical testing.

## 2. CONCEPTUAL FOUNDATIONS AND CLOSEST RESEARCH

### 2.1. Digital transformation as an organizational change

Digitization, digitalization and digital transformation refer to different depths of organizational change. Digitization converts information into digital form; digitalization improves

activities and processes through digital technologies; and digital transformation changes how the organization coordinates activities, makes decisions and creates value [18; 20]. The installation of enterprise resource planning systems, cloud services, industrial internet-of-things technologies, big-data tools or artificial intelligence therefore does not, by itself, establish that a firm has undergone a digital transformation. For this article, enterprise digital transformation means the systemic integration of digital technologies into production, managerial and interorganizational processes, with consequences for information processing, decisions, resource coordination and value creation. This definition is consistent with work on organizational and dynamic capabilities [9; 11; 15] and with Russian-language studies of digital management and industrial transformation [2; 3]. It identifies digital technology as an enabling input, not as an outcome or a substitute for managerial action.

## **2.2. Management optimization as an organizational conversion layer**

Management optimization is not synonymous with cost reduction, automation or improvements in individual key performance indicators. It comprises four related managerial mechanisms: process reconfiguration, decision optimization, resource orchestration and organizational coordination. The mechanisms describe changes in the organization of work and resource use, not merely the acquisition of new equipment or software. The separation between technology, managerial action and economic outcome is fundamental. An analytics system is a technological resource; changing planning procedures in response to its outputs is a managerial conversion; any resulting productivity gain is a potential outcome. Research on process digitalization emphasizes the importance of routines and absorptive capacity [21], while Russian-language studies of management digitalization document the relevance of process redesign and organizational architecture [2]. On this basis, management optimization is defined as organizational reconfiguration through which digital opportunities are incorporated into processes, decisions, resource combinations and coordination practices to support persistent firm capabilities.

## **2.3. Firm capability development**

This framework distinguishes organizational capabilities-innovation capability, human-capital development and organizational agility-from productivity, which is a performance outcome of their use. Capabilities describe a firm's continuing ability to apply knowledge and resources, adapt routines and reorganize activities as conditions change. Research on industrial digital transformation, organizational capabilities and operational improvement supports these links between digital practices, capability development and performance [9; 15; 17].

## **2.4. Industrial upgrading and industrial modernization**

Industrial upgrading is analytically broader than efficiency within an individual firm. Work on firm-level upgrading addresses learning, technology adoption and product innovation [19], while the global value-chain literature differentiates process, product and functional upgrading under different patterns of interfirm governance [8; 12]. A firm's move into higher-value functions may be important, but it does not imply that the industrial system as a whole has undergone equivalent structural change. Industrial modernization is understood here as a qualitative improvement in the technological, productive and functional structure of industrial activities when more productive or higher-value practices spread across firms. Process, product, functional and value-chain upgrading are treated as major structural manifestations of this broader modernization process, rather than as exact synonyms for it. The distinction preserves a separate analytical question: how do firm-level upgrading outcomes become sufficiently widespread or structurally consequential to constitute industry-level modernization?

## **2.5. Research gap and positioning against closest studies**

Studies have examined digital transformation in relation to technical efficiency [22], resource allocation [13; 14], operational performance [17], supply-chain diversification [5] and global value-chain upgrading [6]. The remaining gap concerns the fragmentation of these mechanisms and, in particular, the relatively implicit treatment of the transition from firm-level capabilities to industry-level structure. Table 1 positions the framework against six closely related studies. The framework integrates managerial conversion with a distinct cross-level aggregation mechanism.

**Table 1. Closest studies and theoretical positioning**

| <b>Closest study</b>              | <b>Reported contribution</b>                                              | <b>Distinct focus of this article</b>                                          |
|-----------------------------------|---------------------------------------------------------------------------|--------------------------------------------------------------------------------|
| <b>Feng et al. (2024) [6]</b>     | Digital transformation → GVC upgrading; skill-biased technical change.    | Managerial conversion and the explicit micro–meso link.                        |
| <b>Li (2024) [16]</b>             | Smart transformation → value-chain upgrading via human resources and TFP. | Treats these as firm-level intermediates, not automatically industry outcomes. |
| <b>Jiang et al. (2025) [13]</b>   | Resource allocation through innovation, process optimization and control. | Integrates channels within management optimization.                            |
| <b>Jiang &amp; Li (2024) [14]</b> | Capital/labor allocation and productivity within corporations.            | Separates intra-firm allocation from interfirm reallocation.                   |
| <b>Yang &amp; Yee (2022) [21]</b> | Process digitalization depends on routines and absorptive capacity.       | Models organizational complementarity as a boundary condition.                 |
| <b>Guo et al. (2023) [10]</b>     | Digitalization paradox: TFP may rise while firm performance declines.     | Motivates conditional effects and failure paths.                               |

### 3. MATERIALS AND METHODOLOGY

#### 3.1. Research design

This study uses a targeted, mechanism-oriented conceptual synthesis. It combines theoretical and empirical findings on digital transformation, organizational capabilities, resource allocation and industrial upgrading to develop an explanatory framework. Sources are organized by the stage of the mechanism they address; conditional and conflicting findings inform the boundary conditions and failure paths. The principal outputs are a five-stage conceptual model and four theoretical propositions.

#### 3.2. Construction of the literature base

The literature base was assembled through a targeted, non-systematic search covering digital transformation, management and process digitalization, dynamic capabilities, resource allocation, productivity, industrial and global value-chain upgrading, interfirm resource reallocation, and supply-chain coordination. Studies published during 2021–2026 received priority, with older foundational studies retained when relevant. Selection focused on mechanism-relevant contributions and competing findings rather than exhaustive coverage.

#### 3.3. Inclusion logic and mechanism-based coding

A source was relevant if it addressed at least one substantive link in the proposed mechanism: digital inputs, managerial conversion, firm capabilities and outcomes, cross-firm processes, or upgrading. Descriptions of particular technologies without an organizational or economic mechanism were not central to the synthesis. Negative and ambiguous findings were retained because they identify the limits of positive expectations and help distinguish possible failure paths.

The analysis organized sources along five dimensions: (1) digital inputs, (2) management mechanisms, (3) firm capabilities and outcomes, (4) cross-level mechanisms, and (5) industrial upgrading outcomes. Supporting, conditional and conflicting evidence was considered separately. This procedure allows findings generated at different analytical levels to be related without treating firm-level estimates as direct evidence of industry-level effects.

#### 3.4. Scope of inference

The sources differ in national, sectoral and empirical settings. The proposed micro-to-meso transition is therefore a conceptual inference to be tested with firm- and industry-level evidence, not an independently identified causal estimate.

### 4. RESULTS: AN INTEGRATED CONCEPTUAL MECHANISM

#### 4.1. Digital opportunities and managerial conversion

The synthesis first distinguishes digital information capacity and managerial conversion. Digital integration increases the comparability and availability of production, operational and administrative data. It can reduce informational frictions and make process dependencies visible.

Yet information has practical significance only when it enters planning, monitoring and resource-allocation decisions. Jiang and Li connect internal and external information to improvements in the allocation of capital and labor [14]. In this framework, information transparency is consequently a precondition for managerial reconfiguration, not an industrial outcome in its own right.

Process reconfiguration is a second mechanism. Automating an inefficient workflow reproduces much of the workflow's underlying inefficiency. The managerial change occurs when activities are examined, their sequence or coordination is redesigned, and digital systems help stabilize the resulting practice. The reported association between process digitalization and performance depends on its fit with operational routines and absorptive capacity [21]. Studies of digital transformation practices likewise connect those practices with labor, asset and working-capital efficiency [17]. A third mechanism combines decision optimization with resource orchestration. Digital analytics can make forecasting and monitoring more timely, but the movement from information to action still requires managerial rules, priorities and authority. Resource orchestration concerns which resources are combined, where they are directed and when they are used. Research on corporate resource allocation connects digital transformation to innovation, process optimization and internal control [13]; Russian-language research also relates digitalization to resource conservation in industry [1].

A fourth mechanism is organizational coordination. Digital connectivity can improve coordination among manufacturing, procurement, logistics and financial functions. Beyond the firm's boundaries, shared information and integrated systems may alter supplier and customer relationships. The supply-chain literature associates digital transformation with diversification through lower coordination and transaction costs [5]. The four managerial mechanisms are complementary rather than independent: process redesign is more likely to matter when information is reliable, decision rights are clear and resource changes can be coordinated.

**Proposition 1 (P1).** Digital transformation creates opportunities for management optimization through information integration, process visibility, analytics and digital connectivity. Managerial outcomes arise when these opportunities are embedded in organizational procedures and operating routines.

**Proposition 2 (P2).** Process reconfiguration, decision optimization, resource orchestration and organizational coordination convert digital opportunities into firm capabilities, creating conditions for productivity improvement, stronger innovation capability, human-capital development and organizational agility.

#### **4.2. The cross-level aggregation mechanism**

The synthesis next separates capability development within firms from structural change across an industry. Higher productivity in one enterprise is not identical to industrial upgrading. At the industry level, outcomes depend on how knowledge, technologies, resources, functions and market shares are distributed among firms. Research on firm dynamics highlights the role of entry and exit, selection and reallocation in aggregate productivity [4; 7]. An explicit aggregation mechanism is therefore required between firm capability development and industrial modernization.

The first aggregation channel is diffusion and learning. Managerial and technological practices can move across firms through worker mobility, supplier-buyer relationships, imitation and technological collaboration. Research on upgrading emphasizes learning and technology adoption [19], while studies of global value-chain governance identify the conditions under which suppliers can learn from lead firms [8]. The relevant industry-level question is not merely whether an innovating firm becomes stronger, but whether its practices become available to other firms and improve the capabilities of the productive network.

Competitive selection forms a second channel. Firms differ in their ability to incorporate digital tools into routines and capabilities. These differences may change competitive positions and the allocation of market activity. Selection can contribute to higher aggregate productivity when productive firms expand relative to less productive ones, but that implication depends on the industrial environment. A firm-level productivity gain that does not alter wider competitive dynamics may have limited structural significance.

A third channel is interfirm resource reallocation. Internal resource orchestration involves the use of resources within a firm, whereas interfirm resource reallocation concerns movements of capital, labor, knowledge and economic activity across firms. The distinction matters because internal efficiency improvements may remain localized unless they affect the allocation of resources toward more productive applications [4; 7]. It also explains why firm-level capital and labor allocation findings [13; 14] cannot be equated directly with industry-wide resource allocation.

The fourth channel is supply-chain and value-chain reconfiguration. Digital integration beyond firm boundaries changes coordination costs, partner selection and the location of functions within a network. Prior studies link digital transformation to supply-chain diversification [5] and firms' global value-chain positions [6]. However, an upgraded position for one producer is not itself sufficient for industrial upgrading; broader changes in supplier capabilities, functional specialization and the distribution of value-creating activities are needed. The resulting forms of upgrading are process upgrading (more effective production methods), product upgrading (more sophisticated or higher-quality outputs), functional upgrading (the acquisition of higher-value functions), and value-chain upgrading (a change in the firm's or industry's position within a system of value creation). Their scope is influenced by governance relationships within global value chains [8; 12]. Together they describe structural manifestations of industrial modernization rather than a single undifferentiated outcome.

**Proposition 3 (P3).** Firm capabilities developed through digital transformation and management optimization can contribute to industrial modernization to the extent that their advantages spread or aggregate through interfirm learning, diffusion, competitive selection, resource reallocation, and supply-chain or value-chain reconfiguration (Figure 1; Table 2).

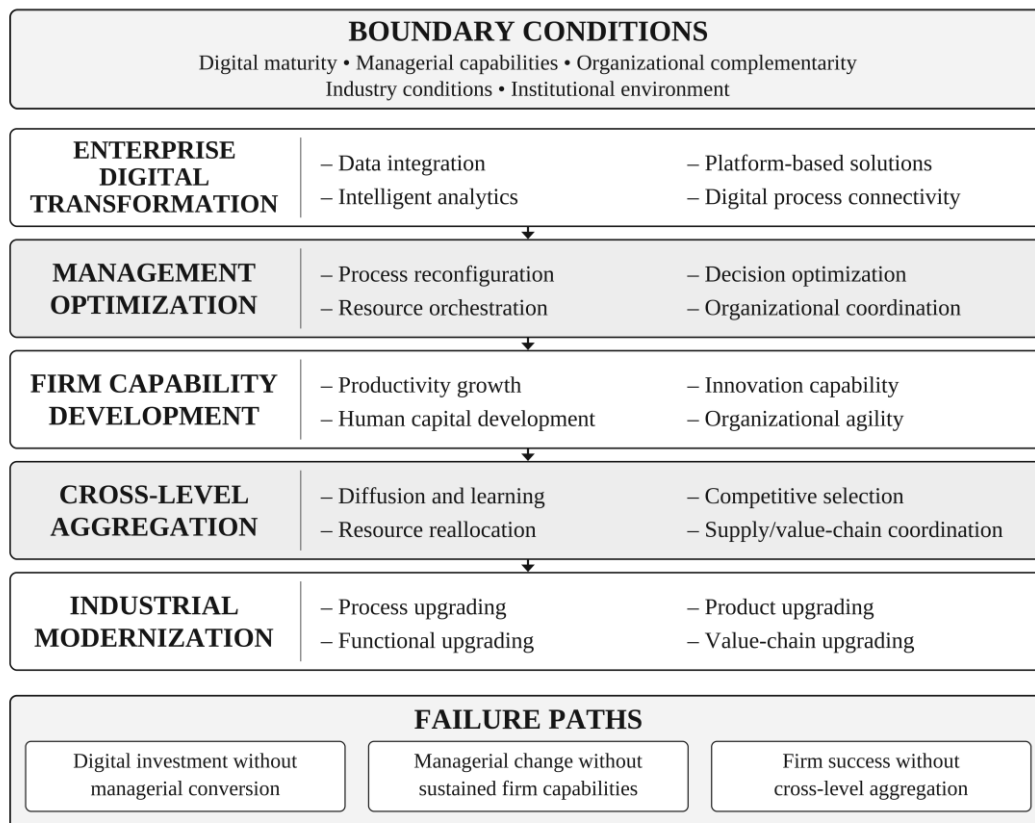


**Figure 1. Integrated multi-level mechanism linking enterprise digital transformation and industrial modernization**

*Source: Developed by the authors.*

**Table 2. Conceptual pathways from enterprise digital transformation to industrial modernization**

| Digital opportunity         | Managerial mechanism → firm outcome                                      | Cross-level channel → upgrading form                                |
|-----------------------------|--------------------------------------------------------------------------|---------------------------------------------------------------------|
| <b>Data integration</b>     | Decision visibility and quality → productivity                           | Diffusion of practices → process upgrading                          |
| <b>Automation</b>           | Process reconfiguration → operational efficiency                         | Competitive selection → process/product upgrading                   |
| <b>Analytics and AI</b>     | Decision optimization and resource orchestration → innovation capability | Capital and labor reallocation → product/functional upgrading       |
| <b>Digital connectivity</b> | Organizational coordination → agility                                    | Interfirm coordination → functional upgrading                       |
| <b>Chain integration</b>    | Supplier/customer coordination → value creation and retention            | Chain reconfiguration → value-chain upgrading                       |
| <b>Digital technologies</b> | Human-capital development → more advanced capabilities                   | Learning and knowledge diffusion → functional/value-chain upgrading |

*Note. Arrows represent proposed conceptual links; they are not estimated causal effects. Source: Authors' synthesis of the cited literature.*

#### **4.3. Boundary conditions and failure paths**

The synthesis also identifies conditions governing the conversion and aggregation stages. Digital maturity concerns the organizational integration of digital opportunities rather than expenditure on technology alone. Managerial capabilities affect the ability to redesign decisions and processes, while organizational complementarity concerns the fit among data, skills, routines and organizational arrangements. Research on dynamic capabilities and process digitalization supports the importance of these alignments [9; 15; 21].

The movement beyond the firm also depends on the competitive and institutional setting. Industry structure, supply-chain relationships, infrastructure, finance, labor mobility, market conditions and data rules may facilitate or obstruct learning and resource movement. Studies report differences in the consequences of digital transformation across firms and environments [13; 22]. The same internal managerial achievement may therefore produce different industry-wide consequences in different contexts. The digitalization paradox provides an important counterexample to an automatically positive mechanism. Guo and colleagues report circumstances in which total factor productivity increases while certain measures of firm performance deteriorate, with managerial myopia affecting the relationship [10]. The framework consequently distinguishes three failure paths: technology is introduced without substantive management reconfiguration; managerial changes do not become durable capabilities; or successful digitally transforming firms fail to generate broader industrial upgrading because diffusion or resource mobility is weak.

**Proposition 4 (P4).** The contribution of enterprise digital transformation to industrial modernization is conditional. Conversion within firms depends on digital maturity, managerial capabilities and organizational complementarity, while the subsequent industry-level outcome depends on industrial and institutional conditions, interfirm diffusion and the possibility of resource reallocation.

## **5. ANALYSIS AND DISCUSSION**

### **5.1. Theoretical contribution**

The first contribution is to distinguish management optimization as an organizational conversion layer. Existing work examines process optimization, internal control, resource allocation, operations and organizational capabilities from partly separate perspectives [9; 13; 14; 15; 17; 21; 22]. This framework places these changes between the adoption of digital technologies and the formation of durable organizational capabilities, making managerial conversion an explicit stage rather than an implicit background condition. The second contribution is an explicit micro-to-meso transition. Existing studies of global value-chain upgrading often evaluate changes in individual firms' functions or positions [6; 16]. Here cross-level aggregation is a separate mechanism comprising diffusion, learning, competitive selection, interfirm resource reallocation

and value-chain coordination. Industrial upgrading is understood as an emergent structural process rather than the mechanical sum of performance improvements recorded by individual firms.

The third contribution is the joint specification of boundary conditions and failure paths. Digital maturity, managerial capability, organizational complementarity and interfirm conditions help explain why managerial conversion and industrial aggregation may fail, consistent with evidence on organizational alignment [21] and the digitalization paradox [10]. The four propositions make these competing pathways available for subsequent empirical assessment.

### 5.2. Managerial and industrial implications

At the firm level, the model shifts attention from purchasing digital tools toward the managerial problem the tools are intended to address. For investments in analytics, enterprise resource planning and industrial Internet of Things infrastructure, the framework highlights which decisions should change, what data are required, who is responsible and how resources will be redeployed. A sequence of problem definition, process redesign, digital solution selection and capability development provides a more coherent managerial logic than reliance on technology acquisition alone. Complementary investment in data governance, workforce skills, cross-functional coordination and change management is relevant for the conversion process. Performance indicators can accordingly capture changes in processes, decision quality and resource utilization rather than only the scale of digital spending. The framework also suggests that industrial policy concerned with modernization should consider knowledge diffusion, supplier development, resource mobility, interoperability and interfirm coordination. Without these connections, isolated digitally advanced firms may coexist with limited industry-wide change.

### 5.3. Comparison with closest studies

Relative to firm-level studies of global value-chain upgrading [6; 16] and resource allocation [13], the framework distinguishes two conversions: digital opportunities into organizational capabilities through managerial change, and firm-level outcomes into industry-level structural change through cross-level aggregation.

## 6. CONCLUSION AND RECOMMENDATIONS

The conceptual synthesis integrates digital transformation, management optimization, firm capabilities, cross-level aggregation and industrial upgrading into a single multi-level framework. Management optimization acts as the organizational conversion layer, while aggregation connects firm capabilities to industrial modernization through learning and diffusion, competitive selection, interfirm resource reallocation and value-chain reconfiguration. Digital maturity, managerial capabilities, organizational complementarity, and industrial and institutional conditions affect these links. The success of individual digitally advanced firms is consequently not identical to structural modernization of an industry. At the firm level, the framework draws attention to processes, capabilities, data governance and coordination alongside technology acquisition; at the industry level, it highlights supplier development, knowledge diffusion and resource mobility. The analysis integrates heterogeneous studies rather than providing a new causal estimate. Future firm–industry research could test each conversion and aggregation stage, compare institutional environments and examine nonlinear responses to digital maturity.

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