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Digital-transformation analytics for developing-economy small enterprises: A complement-internalisation framework

Abstract. Analytics-led digital transformation has become a central instrument of small-enterprise growth, yet the frameworks that describe it were derived almost entirely from firms operating in advanced economies, where the environment supplies most of the assets that analytics requires. Recent statistical evidence has shown that connectivity and digital payment spread rapidly across developing economies over the past decade, while data systems, analytical skills and reliable last-mile infrastructure did not, which has left small enterprises exposed to transformation prescriptions their institutional environment cannot support. The purpose of the study was to develop a conceptual framework that explained analytics-led transformation in developing-economy small enterprises as the sequenced internalisation of the complementary assets that the surrounding institutional environment failed to supply. The study was designed as a theory-development critical review. A theoretical core was assembled from foundational works on complementary assets, absorptive capacity, dynamic capabilities and institutional voids, and a recent-evidence base was assembled through structured searches of scholarly databases across the publication years 2020-2026, restricted principally to peer-reviewed venues and to flagship international statistical reports. Four analytical stages produced the framework: constraint mapping, complement-class derivation, principle formulation and pathway specification. The analysis established four classes of missing complement, namely informational, human-capital, organisational and infrastructural, and specified an internalisation mechanism appropriate to each: self-instrumentation, absorptive-capacity bootstrapping, minimal co-invention and leapfrogging. The synthesis yielded the binding-complement principle, according to which the scarcest complement rather than technological ambition set the pace and the shape of transformation, and a cyclic pathway along which the binding complement migrated as each complement was relieved. The framework offers managers a diagnostic order of operations and policymakers a firm-level vocabulary for targeting ecosystem interventions. All illustration was hypothetical and no empirical data were reported

Keywords: absorptive capacity; dynamic capabilities; self-instrumentation; technology leapfrogging; institutional voids; complementary assets; technology diffusion

INTRODUCTION

The digital environment in which developing-economy small enterprises operate changed materially over the decade preceding this study, but it changed unevenly, and the pattern of that unevenness is what makes the present question urgent. Financial-inclusion measurement by L. Klapper *et al*. (2025), covering the period to 2024, recorded a broad diffusion of mobile-phone ownership and of digital payment across low- and middle-income countries, so that the transactional surface on which analytics could in principle operate became far wider than it had been. Yet the same period produced no comparable convergence in the underlying capacity to use data. The World Bank (2024) documented that cloud services, data-processing capacity and advanced analytical tools remained concentrated in high-income economies, and that an emerging divide in artificial-intelligence

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capability threatened to reproduce, at a higher technological level, the divide that connectivity had begun to close. The OECD (2021), in its policy analysis of small and medium-sized enterprises, reached the same conclusion from the firm side, finding that digital adoption among smaller firms lagged persistently behind that of large firms and that the gap was widest for data-intensive applications rather than for basic connectivity. The relevance of the present study follows directly from this configuration: access has advanced, capability has not, and the frameworks that firms are advised to follow were written for an environment in which capability could be assumed.

That advice originates in a body of scholarship that has grown rapidly and that deserves analytical rather than ceremonial treatment. G. Vial (2019) characterised digital transformation as a process of strategic renewal in which digital technologies reconfigure value creation, operations and organisational structure rather than as an act of technology acquisition. That account established the primacy of organisational change convincingly, yet it left the supply of the non-organisational inputs unexamined, because in the settings it synthesised those inputs were purchasable. Case evidence on smaller firms sharpened the same insight without closing the same gap. M. Matarazzo *et al*. (2021), in a study of Italian small and medium-sized manufacturers, established that digital transformation created customer value only where firms possessed the dynamic capabilities to reconfigure around the technology, and J. Soluk & N. Kammerlander (2021), in a multiple-case study of family-owned Mittelstand firms, established that transformation proceeded through distinguishable stages of process, product and business-model digitalisation, each requiring its own dynamic capabilities. What none of these studies could address is whether the capability-building sequence they describe survives translation into an environment where the external data, the skilled labour and the reliable infrastructure that their firms took for granted are themselves scarce.

Studies conducted in developing and emerging economies confirmed the scarcity but stopped short of a firm-level theory of what to do about it. A.A.F. Alalawneh & S.F. Alkhatib (2021), in an examination of barriers to big-data adoption in developing economies, established that the leading obstacles were infrastructural, informational and skills-related rather than attitudinal, and M.M.H. Shahadat *et al*. (2023), in a large-sample study of small and medium-sized enterprises in an emerging country, established that adoption was driven by perceived cost, top-management support and government support, with organisational readiness exerting no significant effect. J. Díaz-Arancibia *et al*. (2024), in a systematic review of transformation and technology adoption among small firms in developing countries, established that adoption in these settings remained concentrated in basic information systems, with cloud computing and artificial intelligence comparatively rare, and identified community-driven and ecosystem factors as the principal facilitators. Each of these results diagnoses a deficit. None specifies the order in which a single firm should remedy the deficits it faces, and the reviews explicitly call for adoption models tailored to the constraints of developing-country enterprises rather than imported from elsewhere.

A parallel line of enquiry on analytical capability has established what such capability yields once it exists, which is precisely the part of the problem that developing-economy firms have not yet reached. L. Ardito *et al*. (2025), using firm-level evidence from a large sample of European small and medium-sized enterprises, established that the adoption of artificial intelligence was associated with higher revenue growth, and that the association was stronger where the technology was combined with the internet of things and big-data analytics, which the authors interpreted through the literature on digital complementary assets. T. Justy *et al*. (2023), in research on adoption barriers in smaller firms, established that the impediments were managerial, human and informational before they were technological. Taken together, these studies establish that analytical capability pays only in combination with other assets, and they thereby raise, without answering, the question that arises when several of those other assets are institutionally absent rather than merely underdeveloped.

The gap that the present study addressed lies at the junction of these two bodies of work. The transformation and analytics-capability literature explain why technology produces value only in combination with organisational and human complements, but it studies firms embedded in environments that supply most non-organisational complements through the market. The development literature explains why those environments are precisely what developing economies lack, but it studies the phenomenon chiefly at the level of countries, sectors and aggregate diffusion. Neither asks what analytics-led transformation becomes when the complements that one tradition treats as external and given are the very assets the other shows to be missing. The stakes of that question are not confined to the firm. D. Comin & M. Mestieri (2018), using cross-country evidence, established that modern income divergence was driven less by lags in the timing of technology adoption than by persistent gaps in the intensity of use once adoption occurred, and X. Cirera & W.F. Maloney (2017), in their analysis of the innovation paradox, established that firms in developing countries under-invest in technology despite high measured returns because the complementary capabilities needed to capture those returns are absent. Analytics-led transformation at the small-enterprise level is exactly a mechanism of intensive-margin technology use, which makes a firm-level account of complement supply a microfoundation for a macroeconomic puzzle.

The purpose of this study was to develop a conceptual framework that explained analytics-led digital transformation in developing-economy small enterprises as the sequenced internalisation of the complementary assets that the surrounding institutional environment failed to supply. Three tasks were set in order to achieve that purpose. The first task was to map the institutional constraint environment of the developing-economy small enterprise onto the classes of complementary asset that analytics-led transformation requires, distinguishing the gaps that had narrowed from those that persisted. The second task was to specify, for each class, the mechanism by which the firm could supply the complement internally, and to formulate the principle that governed the order in which the mechanisms were applied. The third task was to derive the transformation pathway implied by that principle and to demonstrate its

operation through an explicitly hypothetical illustration. The scientific novelty of the study consisted in the formulation of the binding-complement principle, which established that the scarcest complementary asset rather than technological ambition determined the pace and the shape of analytics-led transformation, and in the integration of the complementary-assets and institutional-voids traditions into a single firm-level pathway that had not previously been specified.

MATERIALS AND METHODS

The study was designed as a theory-development critical review rather than as an empirical investigation, and it reported no primary data. This design was selected because the objective was the construction of a framework capable of organising established results into a coherent account of a phenomenon that had not been theorised at the firm level, rather than the testing of hypotheses derived from an existing account. The theoretical core of the framework was assembled from foundational works in four traditions selected for their direct bearing on the research purpose: the economics of complementary assets and of information technology, which supplies the proposition that technology yields value only in combination with organisational and human assets; the absorptive-capacity tradition, which supplies the account of how firms assimilate knowledge they did not generate; the dynamic-capabilities tradition, which supplies the conception of transformation as ongoing capability renewal; and the development economics of institutional voids and technology diffusion, which supplies the description of the environment in which the developing-economy firm operates. These works were selected on the criterion of foundational status within their tradition, established by citation weight and by their standing as the canonical statement of the construct in question.

The recent-evidence base was assembled through structured searches of scholarly databases, conducted with the Semantic Scholar corpus and with all bibliographic metadata subsequently verified against the Crossref registry, over the publication years 2020-2026. Six search-term families were used: small-enterprise digital transformation in developing and emerging economies; big-data analytics capability and firm performance; absorptive capacity and dynamic capabilities in digitalisation; institutional voids and digital platforms; mobile money, financial technology and financial inclusion; and digital infrastructure, the digital divide and technological leapfrogging. Fifteen topic-specific sweeps across these families returned approximately three hundred records. Inclusion criteria were as follows: publication in a peer-reviewed scholarly journal, with preference given to venues indexed in Scopus or the Web of Science; publication within the stated window; thematic relevance to at least one of the four complement classes or to the current state of digital infrastructure in developing economies; and, for statistical evidence on the environment itself, publication as a flagship statistical or policy report of the World Bank or the Organisation for Economic Co-operation and Development. Excluded were non-peer-reviewed venues, conference abstracts, records without verifiable bibliographic metadata, and studies whose results proved thematically peripheral on inspection of the abstract. Working papers from established economic research programmes were admitted sparingly, and only where no equivalent peer-reviewed result was available. After de-duplication and screening, thirty-six recent studies and reports were retained and merged with a foundational core of eighteen works, yielding the evidence base of fifty-four sources on which the analysis was conducted, thirty-two of them published between 2021 and 2026.

The framework itself was produced through four analytical stages applied in sequence. In the first stage, constraint mapping, the structural features of the developing-economy operating environment reported in the development literature and in current statistical evidence were extracted and restated in the vocabulary of complementary assets, so that each documented constraint was expressed as an asset the environment failed to supply. In the second stage, complement-class derivation, the restated constraints were grouped by the type of asset withheld, and the grouping was tested for exhaustiveness against the requirements of an analytical decision cycle, which yielded four classes. In the third stage, principle formulation, the complementarity result from the economics of information technology was applied to the derived classes in order to establish the rule governing the order of internalisation. In the fourth stage, pathway specification, the principle was translated into a sequence of firm-level actions, each defined by its input, its action and its expected conceptual output, and the sequence was closed into a cycle by the observation that relieving one complement raises the marginal value of the others. The claim advanced by this procedure was not that any single constraint is unique to developing economies, but that the conjunction of the constraints, and their institutional rather than merely quantitative character, changes what transformation requires. The features derived below were stated throughout at the level of the individual small enterprise. The source groups on which the analysis drew, and the specific contribution each made to the study, are set out in Table 1.

Table 1. Source groups used in the analytical synthesis

Source group	Representative sources	Information obtained for the study
Digital transformation and dynamic capabilities	G. Vial (2019), K.S.R. Warner & M. Wäger (2019), J. Soluk & N. Kammerlander (2021)	Conception of transformation as strategic renewal and capability building rather than technology acquisition; staged structure of the transformation process; the organisational locus of change
Economics of information technology, complementarity and analytics capability	D.J. Teece (1986), E. Brynjolfsson & L.M. Hitt (2000), T.H. Davenport & J.G. Harris (2007), H. Chen *et al*. (2012)	The complementary-assets proposition; evidence that computing raises performance only alongside organisational redesign and skills; the definition of analytics as an embedded decision capability
Development economics and institutional voids	C.K. Prahalad (2005), T. Khanna & K.G. Palepu (2010), X. Cirera & W.F. Maloney (2017)	Characterisation of missing market intermediaries; the innovation paradox and missing complementary capabilities; value creation under binding resource constraints

Table 1. Continued

Source group	Representative sources	Information obtained for the study
Current statistical and policy reports	World Bank (2021), A. Demirgüç-Kunt *et al.* (2022), F. Ohnsorge & S. Yu (2022)	Current state of data systems, data infrastructure and data intermediaries; diffusion of digital payment instruments and financial inclusion; the scale and persistence of informality
Recent developing-economy small-enterprise evidence	T. Justy *et al.* (2023), J. Díaz-Arancibia *et al.* (2024), S.S. Ky & C. Rugemintwari (2025)	Ranking of adoption barriers; the prevalence of basic rather than advanced digital tools; firm-level uptake of digital payment instruments in the informal sector

Source: compiled by the author

One limitation of the design was addressed explicitly in the construction of the manuscript. Because no empirical study was conducted, the single extended illustration presented in the Results is hypothetical in its entirety. It refers to no real firm and no real dataset, it reports no numeric results, and it was constructed solely to demonstrate the composition of the principle and the pathway. Any resemblance to a specific enterprise is unintended.

RESULTS

The constraint environment mapped onto four missing complements

The first stage of the analysis restated the documented features of the developing-economy operating environment as classes of complementary asset that the environment fails to supply. A precondition of that restatement was an accurate account of which features had changed. The analysis established that the institutional-voids description, formulated before the diffusion of mobile connectivity and digital payment, remains valid in its structure but requires substantial revision in its particulars, because two of the four complements have been materially relieved from outside the firm while two have not.

The gaps that narrowed were those associated with transaction and connection. Financial-inclusion measurement through 2024 recorded that mobile-phone ownership and the use of digital payment instruments expanded substantially across low- and middle-income economies, extending both the reach of formal financial services and the volume of transactions leaving a digital trace (Klapper *et al.*, 2025); the earlier round of the same measurement programme had already recorded the beginning of that expansion under the conditions of the pandemic (Demirgüç-Kunt *et al.*, 2022). Research on ride-hailing platforms in developing countries established the mechanism behind part of this change: platform firms entering markets characterised by institutional voids performed internally, and at scale, market functions that had previously been distributed or absent, producing markets that were more complete and more formalised even as the platforms created new voids of their own (Heeks *et al.*, 2021). A large cross-country study established the same substitution in the financial domain, showing that mobile-money platforms filled institutional voids by enabling data-based certification, by providing unified access to distributed services and by scaling through network effects to reach previously excluded participants, thereby extending credit access from formal institutions (Agarwal & Assenova, 2024). Firm-level evidence from Burkina Faso established that this reach extended into the informal sector itself, with unregistered businesses adopting and using merchant mobile-money accounts under conditions of considerable uncertainty (Ky & Rugemintwari, 2025). The analysis therefore established that intermediation of payment and of market matching is no longer reliably absent, and that a framework built on the assumption of its absence would misdescribe the current environment.

The gaps that persisted were those associated with data and with capability. Comprehensive assessment of data systems in developing countries established that the institutional apparatus required to convert data into value, comprising statistical capacity, data infrastructure, data-governance rules and the intermediaries that assemble and certify information, remained weak and unevenly distributed, so that the data generated by expanding connectivity were frequently not usable by the firms that generated them (World Bank, 2021). Assessment of digitalisation trends established that cloud services, data-processing capacity and advanced analytical tooling remained concentrated in high-income economies, with an emerging divide in artificial-intelligence capability positioned to widen rather than close (World Bank, 2024). Spatial analysis of the digital divide within Sub-Saharan Africa established that access to internet and broadband continued to be determined by income per capita, capital formation, regulatory efficacy and, notably, electricity infrastructure, with substantial spillovers between neighbouring economies, which indicates that the residual divide is infrastructural and institutional rather than a matter of handset penetration (Myovella *et al.*, 2021). Comparative cross-country analysis established that mobile broadband, rather than internet bandwidth, was the variable through which information and communication technologies advanced human development in developing countries, whereas in developed countries the reverse held, which locates the developing-economy constraint at the level of capacity rather than of connection (Bala, 2024). The analysis accordingly established that the informational and infrastructural environment has become bifurcated: the first, thin layer of digital participation is widely available, and the deeper layer on which analytics depends is not.

Against that updated background, four constraints were mapped onto four missing complements. Absent informational intermediaries. A firm beginning an analytics transformation in an advanced economy inherits a dense supply of external information, including syndicated market research, credit-bureau records, geodemographic databases, industry benchmarks and the transactional residue of formal counterparties. Much of this is a purchasable input. In developing economies, the intermediaries that produce and sell such information are frequently thin or absent, which is the paradigmatic institutional void (Khanna & Palepu, 2010), and the void is compounded by informality, which removes a large share of transactions from

any formal record (Ohnsorge & Yu, 2022). Firm-level survey evidence established that informal competition remained a material feature of the environment faced by formal manufacturing small and medium-sized enterprises in developing and emerging countries, with consequences for their own growth and employment decisions (Amin, 2022), which indicates that the unrecorded segment of the market is not a residual but a structural part of the demand a firm must understand. Where intermediation of business information has begun to emerge, it has done so by substituting soft information for the hard records that do not exist: a multi-case study of Indian banks established that digitalisation was used to verify relationship-based and plan-based information about small enterprises where conventional credit records were unavailable (Hardik, 2023). The analysis established that the missing complement in this class is informational: the firm can neither buy nor borrow the data its analytics require, and a substantial share of the relevant activity is not recorded anywhere.

Thin markets for analytical human capital. Analytics-led transformation requires people who can specify a question, prepare and interrogate data, and translate a result into a decision. Advanced economies supply such people through deep labour markets and a large stock of tacit organisational know-how. Developing economies present thin and geographically concentrated markets for these skills, and the broader managerial capital needed to deploy them well is itself scarce and unevenly distributed (Bloom & Van Reenen, 2010). Because absorptive capacity depends on prior related knowledge (Cohen & Levinthal, 1990), the scarcity is self-reinforcing: a firm holding little existing analytical knowledge finds it correspondingly harder to assimilate more. The analysis established that the missing complement in this class is human-capital: the skills and the absorptive capacity that convert tools into use.

Scarce managerial and organisational capital. Even where data and skills exist, analytics changes nothing unless a decision changes, which requires that a process be redesigned, a decision right reassigned or an incentive realigned so that the output of analysis actually alters behaviour. The complementary-assets literature identified this organisational reconfiguration as the true seat of value, arguing that the largest component of the value created by information technology lies in the organisational transformation it enables rather than in the technology itself, and that the required changes are costly, time-consuming and firm-specific (Brynjolfsson & Hitt, 2000). Firm-level evidence established that information technology, workplace reorganisation and skilled labour operate as mutual complements, so that the return to any one of them rises with the presence of the others (Bresnahan *et al.*, 2002). This is the one complement that must be co-invented within the firm even in advanced economies. In developing economies, the difficulty is compounded, because average managerial practice is less developed and because owner-centric small enterprises frequently lack the delegation structures that data-driven decision-making presupposes. The analysis established that the missing complement in this class is organisational: the redesigned processes and decision rights without which analysis is inert.

Intermittent but leapfroggable infrastructure. Analytics presupposes an infrastructure of connectivity, power, computation and storage. In developing economies this infrastructure is real but uneven, dependable in major urban centres and intermittent beyond them, with electricity provision and regulatory quality among its binding determinants, as the spatial evidence reviewed above established. The constraint is nonetheless double-edged. The same conditions that make legacy on-premise digitisation impractical also open the possibility of leapfrogging directly to mobile-first, cloud-hosted and frugally engineered architectures that skip the stages advanced economies passed through (Steinmueller, 2001). Evidence on the arrival of fast internet in Africa established substantial positive effects on employment (Hjort & Poulsen, 2019), and subsequent evidence on the expansion of third-generation mobile internet across developing countries established increases in labour-force participation and in small-enterprise operation, with distinct effects by gender (Chiplunkar & Goldberg, 2022). The analysis established that the missing complement in this class is infrastructural, but that, unlike the other three, it can often be supplied by adoption rather than by construction, provided the firm resists the temptation to replicate the advanced-economy technology stack.

The synthesis yielded a common structure across the four features. Each corresponds to a complement that analytics-led transformation requires and that the advanced-economy firm largely obtains from its environment: information, skilled human capital, organisational reconfiguration and infrastructure. In the advanced-economy setting three of the four, all but the organisational, are substantially supplied by the market and by institutions, so that the transformation task reduces mostly to internal organisational change plugged into an otherwise supportive environment. In the developing-economy setting the environment supplies far less, and the firm confronts the prospect of having to supply several complements at once, from within. This shift, from internalising one complement into a rich environment to internalising several into a sparse one, is what the analysis established as the structural distinction of developing-economy transformation, and it is the condition that the framework below was designed to manage.

The four complements as objects of internalisation

The second element of the framework specified each complement as an object the firm must supply internally when the environment does not, together with the internalisation mechanism appropriate to it. The mechanisms below are author-derived outputs of the synthesis; the results cited within them are the literature-supported propositions on which each mechanism rests. The informational complement is internalised through self-instrumentation. When no intermediary sells the data and informality hides much of the market, the firm must manufacture its own information by instrumenting its own operations and points of contact, converting every interaction it does control into a recorded, structured observation. A point of sale becomes a data-collection instrument; a delivery route becomes a source of geographic demand signal; a customer conversation becomes a captured, coded field. Self-instrumentation reconceives data not as an input the firm receives but as an output the firm produces, and the analysis established

it as the firm-level substitute for the absent informational intermediary. The mechanism is consistent with the emergence of soft-information intermediation in thin-record environments established above, with the difference that the framework locates the production of the substitute record inside the transacting firm rather than inside the lender. It also reframes analytics, at least initially, as a means of building the firm's proprietary informational asset rather than of mining a pre-existing one.

The human-capital complement is internalised through absorptive-capacity bootstrapping. Because skilled analysts are scarce and absorptive capacity is low, the firm cannot hire its way to capability in a thin market. It must instead bootstrap: begin with a small, deliberately cultivated nucleus of analytical understanding, leverage external knowledge aggressively through open methods, cloud-hosted tooling, advisory relationships and increasingly capable machine-learning systems that lower the skill threshold for a given analytical task, and expand the internal knowledge base incrementally so that each increment raises the capacity to absorb the next (Cohen & Levinthal, 1990). Evidence from small and medium-sized enterprises established that potential absorptive capacity, comprising the acquisition and assimilation of external knowledge, drove both strategic flexibility and business-model innovation, while realised absorptive capacity raised flexibility directly (Miroshnychenko *et al.*, 2021), which supports the framework's emphasis on the acquisition stage as the point of entry for a resource-constrained firm. Machine-learning tools enter the framework strictly as instruments that reduce the scarcity of the human-capital complement rather than as the subject of transformation; firm-level evidence that the adoption of artificial intelligence was associated with the highest revenue growth where it was combined with analytics and connected devices is consistent with that instrumental reading (Ardito *et al.*, 2025). Their role, in the framework's terms, is to let a small team accomplish what a large one otherwise would.

The organisational complement is internalised through minimal co-invention. Since analysis changes nothing unless a decision changes, the firm must redesign the specific process, decision right or incentive that a given analytical output is meant to influence. Firm-level evidence from eighty-two developing economies established that the productivity premium associated with digital-technology adoption operated jointly with other firm choices, including managerial experience and exporting, and the authors explicitly examined complementarities among those choices (Pena *et al.*, 2020), which locates the same complementarity result in the setting the framework addresses. The discipline the framework imposes is minimality: the firm co-invents the smallest organisational change that lets one decision become data-driven, rather than attempting an enterprise-wide restructuring it lacks the managerial capital to execute. Minimal co-invention respects the scarcity of managerial capital by spending it where a single, observable decision will change, and it builds the delegation and routine that later, larger reconfigurations will require.

The infrastructural complement is internalised through leapfrogging. Rather than constructing the legacy stack that advanced-economy firms accumulated over decades, the developing-economy firm adopts mobile-first, cloud-hosted and frugally engineered infrastructure that matches its constraints and skips the stages it need not repeat (Steinmueller, 2001). The mechanism draws on the established observation that firms in resource-constrained settings create value by engineering around constraints rather than assuming them away (Prahalad, 2005; Zeschky *et al.*, 2011). Of the four complements this is the one most often supplied by adoption rather than by construction, which is why leapfrogging can relieve it comparatively quickly, and why the analysis established that it is frequently not the binding complement once the firm resists over-building.

The governing principle:
The binding complement governs

The synthesis yielded a single governing principle: in a developing-economy small enterprise, the pace and the shape of analytics-led transformation were set not by technological ambition but by the binding complement, which is the scarcest of the complementary assets the transformation requires. This principle inverts the implicit logic of the transplanted playbook, which sequences transformation by technological maturity, acquiring the platform, then the data, then the models, then the use cases. Under the binding-complement principle, the firm sequences transformation by scarcity: it identifies which complement is most limiting at a given moment, concentrates its effort on internalising that complement, and treats technology acquisition as subordinate to, and paced by, complement supply.

The principle follows directly from the complementary-assets result. If information technology, organisational change and skilled labour are mutual complements, so that the return to each rise with the presence of the others (Bresnahan *et al.*, 2002), then investment in any single complement while another remains at zero yields little. The proposition has a deeper root in the analysis of complementary assets, which established that the profits from an innovation flow not to the innovator alone but to whoever controls the specialised assets the innovation requires (Teece, 1986). A firm that buys sophisticated analytical software while holding no usable data, or that accumulates data it has no organisational mechanism to act upon, has not transformed; it has stranded capital in an unbalanced complement bundle. The binding-complement principle is the operational discipline that keeps the bundle balanced, directing effort to the margin at which the complementary system is weakest, because that is the margin at which additional effort raises the productivity of everything else.

Two features distinguish this principle from a maturity ladder and from an investment-prioritisation rule, and both distinctions matter for its application. It is not a maturity ladder, because the binding complement is not a fixed stage through which every firm passes in the same order; it is a firm-specific and moment-specific diagnosis that can differ across enterprises facing the same technology and that migrates within a single firm over time. It is not a rule for ranking capital expenditures by financial return, because the complements it sequences are predominantly capabilities, comprising information the firm manufactures, skills it cultivates and processes it redesigns, most of which are

built through organisational effort rather than purchased, and because the principle is silent on how any infrastructure spend should be financed. What the principle governs is the order in which capabilities are internalised, not the appraisal of an investment.

The framework that follows from the principle describes a process of becoming rather than a state to be measured or a purchase to be justified. Its unit of analysis is the changing configuration of the firm's complementary system as it internalises, in sequence, the assets its environment withholds. Transformation, in this account, is the trajectory along which the binding complement is repeatedly identified and relieved until the complementary system is balanced enough to sustain data-driven operation. This is a deliberately dynamic, capability-building conception, aligned with the view of transformation as the ongoing renewal of higher-order routines through which a firm adapts its ordinary capabilities to change (Teece, 2007).

Accordingly, the principle establishes a practical criterion for advancing the transformation: the firm should proceed to the next technological or organisational step only after the currently binding complement has been relieved sufficiently for another constraint to become dominant. This criterion converts complementarity from an explanatory proposition into a sequencing rule and provides the basis for the cyclic pathway presented in the following subsection.

The transformation pathway

Before the pathway is specified, its structure may be stated as a whole. Figure 1 presents the framework schematically. Its upper register shows the four complement classes, each paired with the internalisation mechanism derived above. Its centre shows the binding-complement logic, in which a diagnosis for one specific decision selects a single complement as the current constraint and directs effort to that complement alone. Its lower register shows the cyclic migration of the constraint, in which the relief of one complement raises the marginal value of the remaining three and thereby shifts the binding complement to a new position, returning the firm to the diagnostic step for the next decision. The figure is therefore not a maturity staircase but a closed loop with a rotating point of entry, and it should be read in that way.

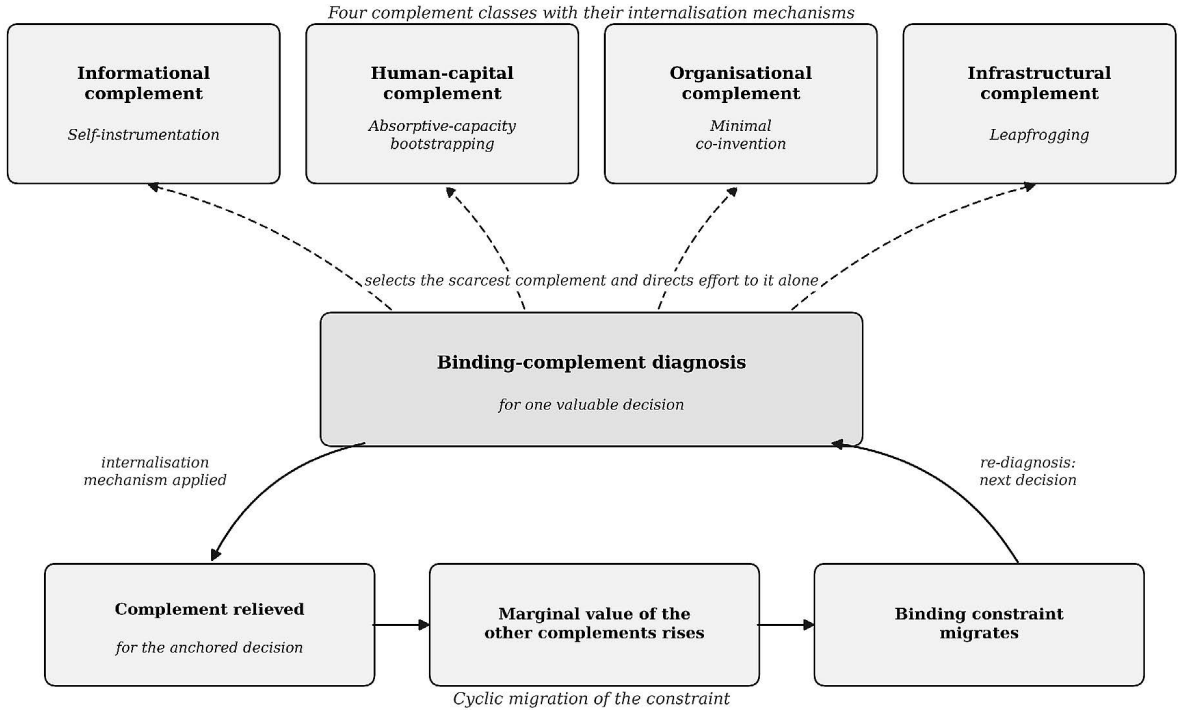


Figure 1. The complement-internalisation framework: four complement classes with their internalisation mechanisms, the binding-complement diagnosis, and the cyclic migration of the constraint

Source: developed by the author

The pathway that the figure formalises was specified as a repeating cycle rather than a staircase, and its stages are logical rather than strictly temporal, so that several may proceed in parallel and the cycle repeats as the binding complement migrates. Each stage is characterised below by its input, the action it requires and the conceptual output it is expected to produce. The pathway opens with the diagnosis of the binding complement. Its input is a single valuable decision that the firm wishes to render data-driven, selected deliberately rather than a general aspiration to digital maturity. The action is an assessment of which of the four complements is most limiting for that decision specifically, framed not as the question of whether the firm is data-mature but as the question of whether, for this decision, the constraint is the absence of data, the absence of the skill to analyse it, the absence of the organisational means to act on it, or the absence of the infrastructure to run it. The expected output is a named binding complement, which directs all subsequent effort and, equally importantly, licenses the firm to defer the other three.

Where the diagnosis identifies the informational complement, as it frequently does at the outset given absent intermediaries and the scale of informality, the pathway proceeds to the manufacture of information through self-instrumentation. The input is the set of interactions the firm already controls, comprising its transactions, its routes, its stock movements and its customer conversations. The action is the conversion of those interactions into structured, recorded observations, undertaken instead of waiting for external data that will not arrive. The expected output is the firm's first proprietary dataset, which is also its first asset that competitors cannot purchase.

The pathway then requires the co-invention of the minimal organisational change, and the analysis established that this stage should be initiated before or alongside any modelling rather than after it. The input is the specific decision identified at diagnosis, together with the person or role that currently makes it. The action is the redesign of the one process, decision right or incentive through which the intended decision will actually change, so that when an analytical result exists a mechanism already exists to act on it. The expected output is an accountable decision rule of minimal scope, and the reason for sequencing it early is to prevent the common failure in which insight is produced but never used because nobody is empowered or obliged to use it.

Bootstrapping absorptive capacity with borrowed knowledge follows. The input is whatever analytical understanding the firm already possesses, however slight, together with the external knowledge it can reach. The action is the cultivation of a small analytical nucleus and the aggressive leverage of external methods, cloud tooling, advisory relationships and machine-learning systems that lower the skill threshold for the task at hand. The expected output is an incrementally enlarged internal knowledge base in which each increment raises the capacity to absorb the next, which is the property that makes the mechanism self-reinforcing rather than merely additive.

Leapfrogging the infrastructure completes the outward arc of the cycle. The input is the technical requirement implied by the decision, sized to that decision alone. The action is the adoption of frugal, mobile-first and cloud-hosted infrastructure, avoiding both the legacy stack and the over-building that would strand scarce capital. The expected output is a technical base adequate to the decision and no larger, which preserves the firm's capacity to redirect resources when the binding complement migrates.

The cycle closes with re-diagnosis. Its input is the relieved complement and the decision now rendered data-driven; its action is the repetition of the diagnostic step for the next decision; and its expected output is a new binding complement, typically different from the last. Relieving one complement raises the marginal value of the others and therefore tends to shift the constraint elsewhere, so that a firm which solves its data problem commonly discovers that the organisational complement now binds. The transformation accordingly advances as a sequence of balanced, decision-anchored increments rather than as a single technological leap.

Three properties distinguish this pathway from the transplanted one, and the analysis established each as a consequence of the governing principle rather than as an independent recommendation. The pathway keeps the complement bundle balanced, so that scarce effort is never stranded against a complement held at zero. It is decision-anchored, so that every increment is tied to a specific decision whose change is observable, which both disciplines scope and generates the evidence that sustains internal support for the transformation. And it is self-propelling, because each relieved complement raises the return to relieving the next, converting transformation from a large and discouraging leap into a series of achievable moves. In development terms, the pathway constitutes a firm-level mechanism for raising the intensity of technology use, which is the margin on which cross-country evidence locates the divergence of incomes (Comin & Mestieri, 2018), by building in sequence the very complementary capabilities whose absence the innovation paradox identifies.

The contrast with the transplanted path clarifies what is at stake. That path is roughly linear and technology-led: assess digital maturity, select a platform, ingest available data, deploy models and scale use cases, drawing throughout on an environment that supplies data, talent and infrastructure on demand. Transplanted into a developing-economy small enterprise, it fails in a characteristic way. The firm acquires capability at the technological margin while the informational, human and organisational margins remain near zero, and because the complements are mutual, the acquired technology delivers little. The firm then concludes, wrongly, that analytics does not work for firms like it, when in fact it has reproduced the productivity paradox at its own scale by investing in an unbalanced complement bundle.

The constraint-to-outcome mapping

The four elements of the framework are brought together in Table 2, which sets out, for each institutional constraint, the current evidence establishing its status, the complement the constraint renders missing, the mechanism by which the firm internalises that complement, the managerial action the mechanism implies and the outcome the analysis expects it to produce.

Table 2. Institutional constraints, missing complements, internalisation mechanisms and expected outcomes

Institutional constraint	Current evidence (source)	Missing complement	Internalisation mechanism	Managerial action	Expected outcome
Thin or absent informational intermediaries; a large share of transactions unrecorded	Informal competition remains a structural feature of the markets faced by formal small and medium-sized enterprises (Amin, 2022); intermediation emerges by substituting verified soft information for absent hard records (Hardik, 2023)	Informational	Self-instrumentation	Instrument the interactions the firm controls, converting points of sale, routes and customer contacts into structured records	A proprietary dataset that cannot be purchased by competitors and that supports one named decision

Table 2. Continued

Institutional constraint	Current evidence (source)	Missing complement	Internalisation mechanism	Managerial action	Expected outcome
Thin and geographically concentrated markets for analytical skills; low prior analytical knowledge	Infrastructural, informational and skills deficits lead the barriers to data-intensive adoption in developing economies (Alalawneh & Alkhatib, 2021); potential absorptive capacity drives strategic flexibility and business-model innovation in smaller firms (Miroshnychenko *et al.*, 2021)	Human-capital	Absorptive-capacity bootstrapping	Cultivate a small analytical nucleus and borrow method, tooling and advisory capacity rather than attempt to hire in a thin market	Incremental internal capability in which each increment raises the capacity to absorb the next
Scarce managerial capital; owner-centric structures without delegated decision rights	Management practice varies widely across firms and countries and accounts for a meaningful share of productivity differences (Bloom & Van Reenen, 2010); top-management support and perceived cost, rather than organisational readiness, determine adoption in emerging-country small enterprises (Shahadat *et al.*, 2023)	Organisational	Minimal co-invention	Redesign the single process, decision right or incentive through which one decision will change, and name the person accountable for it	An accountable decision rule of minimal scope, ready to act on an analytical result when it exists
Uneven last-mile connectivity, power and computation beyond major urban centres	The residual divide is driven by income, capital formation, regulatory efficacy and electricity infrastructure, with cross-border spillovers (Myovella *et al.*, 2021); mobile broadband rather than bandwidth is the channel through which developing economies gain (Bala, 2024)	Infrastructural	Leapfrogging	Adopt mobile-first, cloud-hosted and frugally engineered infrastructure sized to the decision, with a defined fallback for connectivity failure	A technical base adequate to the decision and no larger, preserving capital for the next binding complement

Note: the constraint and evidence columns were compiled from the peer-reviewed studies and statistical reports cited within the table, all published between 2010 and 2025 and selected according to the inclusion criteria stated in the Materials and Methods; the missing-complement, mechanism, action and outcome columns are author-derived outputs of the analytical synthesis and are not attributable to the cited sources
Source: compiled by the author

The illustration below was constructed to demonstrate how the elements established above compose into a single sequence. It is hypothetical in its entirety, refers to no real firm and no real dataset, and reports no numeric results. Its assumptions are stated explicitly and are the author's; the propositions on which its reasoning depends are the literature-supported results established earlier in this section. It demonstrates the framework rather than substituting for it, and no part of it constitutes evidence.

The assumptions are as follows. A mid-sized grocery and general-merchandise retailer is posited, operating a modest number of outlets across a developing economy, with ambitions to move from intuition-led buying and promotion towards analytics-led operation. It is assumed to have a rudimentary point-of-sale system in its larger stores, no external market data of any usefulness, one numerate manager without formal analytical training, and connectivity that is dependable in the capital and erratic elsewhere. These assumptions were chosen because each instantiates one of the four constraints established in the constraint mapping: the absence of purchasable market data instantiates the informational void, the single untrained manager instantiates the thin skills market, the absence of a delegated ordering rule instantiates scarce organisational capital, and the uneven connectivity instantiates the infrastructural constraint.

The transplanted playbook would have this retailer license a business-intelligence platform and a demand-forecasting module and wait for value to appear. Under the analysis established above, it would wait in vain, because it would have invested at the technological margin while the informational, human and organisational margins stood empty, which is the failure mode the complementarity result predicts.

Under the framework, the retailer would begin by diagnosing the binding complement for one valuable decision, taken here to be the quantity of a small set of perishable staples to order for each outlet each week. The diagnosis, following the constraint mapping, identifies the informational complement as binding, because the firm can neither buy demand data nor yet record its own reliably. The retailer therefore self-instruments, turning its point-of-sale terminals and, where those are absent, a simple structured manual count into instruments that produce a proprietary record of sales by outlet and item. In parallel it co-invents the minimal organisational change, adopting a single explicit rule that the weekly order for these staples will follow the analysis rather than the branch manager's habit, with one named person accountable for the decision, so that when a forecast exists a mechanism exists to act on it. It bootstraps absorptive capacity by pairing its one numerate manager with cloud-hosted, low-code forecasting tools and external guidance, keeping the analytical task within reach of a small team. It leapfrogs infrastructure by hosting everything in the cloud and delivering the weekly order recommendations to outlet managers on mobile devices, with a coarse fallback rule for weeks in which connectivity fails, which is the accommodation the evidence on residual infrastructural unevenness makes necessary. Having relieved the informational complement and, minimally, the organisational and infrastructural complements for this one decision, the retailer re-diagnoses and finds that the binding complement has migrated: extending analytics from ordering to promotion now binds on the

organisational complement, because promotion decisions are dispersed across branch managers with no mechanism to coordinate them. The next increment addresses that, and the cycle repeats.

The value of the exercise lies not in any number, none of which is claimed, but in the order of operations the framework imposes. It refuses to let the firm invest in technology ahead of the complements that technology requires, it anchors each step to a decision whose change can be observed, and it advances the transformation as a sequence of balanced moves rather than as a single and probably stranded technological purchase.

DISCUSSION

The theoretical contribution of the study lay in the joining of two literatures that developed apart and in the specification of the construct their junction required. Analytics-led transformation in a developing-economy small enterprise was established as the sequenced internal supply of the complements the environment fails to provide, governed by the discipline that the binding complement, and not the technology, paces the process. This reframes transformation from an act of acquisition into an act of institutional substitution performed at the level of the single firm, and it extends the dynamic-capabilities conception of transformation as continuous renewal developed by D.J. Teece (2007) into an environment where the objects of renewal include assets the firm would ordinarily obtain from outside. The remainder of this section situates that contribution against recent studies not drawn upon in the Introduction, comparing each result with the framework and identifying what the framework adds.

P. Mikalef *et al*. (2020), in research on big-data analytics capability, established that such capability improved competitive performance only indirectly, through dynamic capabilities that in turn strengthened marketing and technological capabilities, with no significant direct effect. The framework agrees with the mediation structure and specifies its precondition. The mediating capabilities that this research measures presuppose an informational base and an organisational apparatus that the surveyed firms possessed; the framework's added value is to describe how a firm assembles those preconditions when the environment does not supply them, which locates the developing-economy problem one step earlier in the same causal chain. An earlier synthesis of case and review evidence by S.F. Wamba *et al*. (2015) reached a compatible conclusion about the organisational conditions under which analytics generates impact, and the framework preserves that conclusion while restricting the conditions under which it can be acted upon.

J. Lin *et al*. (2024), using evidence from firms operating under environmental dynamism, established that big-data analytics capability improved performance indirectly, through proactive and reactive organisational resilience, rather than directly. The framework agrees that the effect of analytical capability is transmitted rather than direct, and its added value is to specify what a firm must internalise before any such transmission can begin. A qualitative study of agrifood small enterprises by R. Cannas (2023) reached a compatible conclusion from the capability side, finding that the decisive capabilities were relational and territorial rather than technical, which the framework accommodates by treating the organisational complement rather than the technological one as the seat of change.

F. Morimura & Y. Sakagawa (2023), using retail-sector evidence, established that both responsive and proactive market orientations raised analytics capability and that capability fully mediated the effect of orientation on firm performance. This result agrees with the framework›s insistence that analytics is a capability rather than a purchase, and it differs from the framework in its implicit assumption that market orientation can be exercised through available market information. The framework's added value in the retail setting, which is the setting of its own illustration, is to specify self-instrumentation as the means by which a firm without purchasable market data constructs the informational base that market orientation would otherwise draw upon.

M. Anwar *et al*. (2024), in work on the antecedents of big-data analytics adoption among small and medium-sized enterprises, examined the relationship between adoption, decision quality and environmental performance. The framework agrees that decision quality is the appropriate proximate outcome of analytics rather than performance measured directly, and it converges with this emphasis through the decision-anchoring property of the pathway. Its added value is to make the decision, rather than the adoption, the unit at which transformation is planned, so that the antecedents of adoption are subordinated to the requirements of a specific decision the firm intends to change.

T. Hongyun *et al*. (2023), using evidence from small and medium-sized enterprises, established that analytics capability moderated the relationships through which digital transformation and digital service capability influenced innovation performance, and that the moderation was not uniformly positive across the relationships tested. The framework agrees that analytics capability operates conditionally rather than universally and differs by supplying an explanation for the non-uniformity: where the complementary bundle is unbalanced, an increment of analytical capability can depress rather than raise performance, because it draws effort towards a margin whose complements are absent. The framework's added value is therefore to predict where such conditional effects should appear.

C.-Y. Chang *et al*. (2025), in a study of digital-transformation anxiety, established that this construct depressed both absorptive capacity and dynamic capability, that both in turn raised digital innovation performance, and that dynamic capability was the stronger mediator. This result agrees with the framework's treatment of absorptive capacity as the operative constraint on the human-capital complement, and it adds a psychological antecedent the framework does not model. Conversely, the framework contributes an explanation for why anxiety should be prevalent in resource-constrained settings: a firm advised to pursue an enterprise-wide, technology-led transformation it cannot resource has good reason for apprehension, whereas the minimality discipline of the pathway reduces the scope of any single commitment to a level the firm can absorb.

A. Tariq *et al*. (2025), in research on digital entrepreneurial firms in a developing country, established that organisational improvisation raised digital innovation

performance, that knowledge-worker productivity mediated the relationship, and that resource constraints weakened it. The framework agrees that improvisation under constraint is productive and differs in the discipline it imposes upon it. Improvisation as measured in that study is unstructured by construction; the framework's added value is to give improvisation a direction, in that the binding-complement diagnosis specifies which margin the firm should improvise at, which is precisely the margin where the study finds resource constraints most damaging.

I.J. Akpan *et al*. (2022), using evidence assembled during the pandemic, established that small enterprises in emerging and developing markets remained largely unreached by cloud computing, big data and predictive analytics, and that the absence of these technologies conditioned their capacity to operate under disruption. The framework agrees with the diagnosis and differs on the inference commonly drawn from it. Where such evidence is often read as a case for accelerating technology adoption, the framework establishes that adoption in advance of complement supply reproduces the failure it is meant to remedy; its added value is to convert an adoption gap into an ordered programme of complement internalisation.

A.A. Oloyede *et al*. (2023), in a systematic review and meta-analysis of digital-economy measurement in developing countries, established that the effects of digitalisation remain poorly quantified because datasets are scarce and definitions vary between countries. This result agrees with the framework's central premise from the measurement side, since the informational void it describes at the level of the firm has an exact counterpart at the level of the national statistical system. The framework's added value is to show that a firm need not wait for the measurement problem to be solved externally, because self-instrumentation produces, for the firm's own decisions, the record that the aggregate system does not yet provide.

A. Nagy *et al*. (2025), using comparative evidence on financial-technology adoption among small enterprises, established that technological and environmental factors significantly influenced adoption while organisational factors did not, and that the pattern differed between a developed and a developing economy, with trust in government contributing to the difference. The framework agrees that the environment carries more explanatory weight in developing settings and differs in its normative implication: whereas the adoption literature treats environmental factors as exogenous conditions to be waited upon, the framework treats the corresponding complements as objects the firm can partially internalise. Y. Liu *et al*. (2025), in research on digital crowdfunding platforms, similarly established that platform-based mechanisms supported the sustainability of small enterprises in emerging markets through entrepreneurial competency, social capital and supply-chain trust, which is consistent with the framework's account of platforms as partial substitutes for missing intermediaries while confirming that the substitution depends on firm-level capabilities the platform does not supply.

T.A. Liedong *et al*. (2020), in a review of the institutional-voids literature, established that the evidence on how voids affect firms' resource commitment in emerging markets remained equivocal, and mapped the conceptualisations, mechanisms and contingencies through which the relationship has been theorised. The framework agrees that the relationship is contingent and offers a specific resolution of part of the equivocation: it predicts that resource commitment under voids is best understood not as a single decision to commit or withhold but as a sequence of commitments ordered by which complement currently binds. J. Pena *et al*. (2020) reported firm-level estimates from eighty-two developing economies that established productivity premiums associated with digital-technology adoption operating jointly with other firm choices, thereby supporting the complementarity premise on which that prediction rests while leaving the ordering question, which the framework addresses, open.

CONCLUSIONS

The study established that analytics-led digital transformation in developing-economy small enterprises was not primarily a technology-acquisition process, but the sequenced internalisation of assets that the external environment did not reliably supply. Four binding complement classes were identified: informational, human-capital, organisational and infrastructural. Mobile connectivity, digital payments and platform intermediation had reduced transaction and connection gaps, whereas deficits in usable data, analytical skills, managerial capital and reliable last-mile infrastructure remained decisive. A corresponding mechanism was specified for each class: self-instrumentation, absorptive-capacity bootstrapping, minimal co-invention and leapfrogging. Their integration yielded the binding-complement principle, according to which the scarcest complement, rather than technological ambition, determined the pace and configuration of transformation. The resulting cyclic pathway required a firm to select one valuable decision, diagnose the complement constraining it, relieve that constraint at the smallest viable scale and repeat the diagnosis as the constraint migrated. The hypothetical illustration demonstrated the logical operation of this sequence without presenting empirical results.

The scientific contribution consisted in joining the complementary-assets and institutional-voids traditions within a single firm-level framework and in explaining the gap between technology access and productive use. For managers and owners, the framework replaced a broad mandate to become data-driven with an ordered diagnostic: begin with one consequential decision, build only the information and capability required for it, make the minimum organisational change needed to act on the analysis, and adopt frugal infrastructure suited to the task. For policymakers, it provided a basis for targeting shared data intermediaries, analytical skills, management practices and reliable connectivity according to the complement that constrained a defined group of enterprises. The study was limited by its conceptual design, the absence of primary empirical data, the heterogeneity hidden by the general category of developing economies and the lack of a validated measure of complement scarcity. Further research should compare complement-internalisation sequencing with technology-led sequencing across matched enterprises, calibrate the framework in specific national and sectoral settings, and develop a measure capable of identifying the binding complement and tracking its migration over time. Such validation would establish when the framework im-

proves decision quality, resource allocation and the sustainability of digital transformation.

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Аналітика цифрової трансформації малих підприємств у країнах, що розвиваються: концептуальна основа інтерналізації комплементарних активів

Анотація. Цифрова трансформація малих підприємств, що ґрунтується на аналітиці, стала центральним інструментом їхнього зростання, однак концептуальні основи, які її описують, майже повністю були розроблені на основі діяльності підприємств у розвинених країнах, де середовище забезпечує більшість активів, необхідних для аналітики. Останні статистичні дані засвідчили, що протягом останнього десятиліття у країнах, що розвиваються, швидко поширювалися підключення до цифрових мереж і цифрові платежі, тоді як системи даних, аналітичні навички та надійна інфраструктура останньої милі – ні. Унаслідок цього малі підприємства опинилися під впливом рекомендацій щодо трансформації, які їхнє інституційне середовище не здатне підтримати. Метою дослідження було розробити концептуальну основу, яка пояснювала б цифрову трансформацію малих підприємств у країнах, що розвиваються, на основі аналітики як послідовну інтерналізацію комплементарних активів, які навколишнє інституційне середовище не змогло забезпечити. Дослідження було проведене у форматі критичного огляду з метою розвитку теорії. Теоретичне ядро було сформоване на основі фундаментальних праць щодо комплементарних активів, абсорбційної спроможності, динамічних спроможностей та інституційних прогалин, а база сучасних доказів за результатами структурованого пошуку в наукових базах даних за 2020-2026 роки, переважно з обмеженням до рецензованих видань і провідних міжнародних статистичних звітів. Формуванню концептуальної основи сприяли чотири аналітичні етапи: картування обмежень, визначення класів комплементарних активів, формулювання основного принципу та визначення траєкторії. У результаті аналізу було виокремлено чотири класи відсутніх комплементарних активів, а саме інформаційні, активи людського капіталу, організаційні та інфраструктурні, і визначено відповідний механізм їхньої інтерналізації: самоінструменталізацію, нарощування абсорбційної спроможності, мінімальне спільне винахідництво та технологічний стрибок. Узагальнення дало змогу сформулювати принцип визначального комплементарного активу, відповідно до якого темп і форма трансформації визначаються не технологічними амбіціями, а найдефіцитнішим комплементарним активом, а також циклічну траєкторію, за якою визначальний комплементарний актив змінюється в міру усунення дефіциту кожного з активів. Запропонована концептуальна основа надає менеджерам діагностичний порядок дій, а політикам – термінологічний інструментарій на рівні підприємства для цілеспрямованого формування заходів на рівні екосистеми. Усі приклади є гіпотетичними, і емпіричні дані не наводилися

Ключові слова: абсорбційна спроможність; динамічні спроможності; самоінструменталізація; технологічний стрибок; інституційні прогалини; комплементарні активи; дифузія технологій