



# Achieving scalability in incumbent firms: Testing and extending the four-stage development model

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## ARTICLE INFO

### Keywords:

Scalability  
Firm Growth  
Mediation  
Path Analysis  
Structural Equation Modelling  
Incumbent Firms

## ABSTRACT

Scalability—a firm's ability to develop the conditions for potential hypergrowth—has typically been studied in start-ups. This study shifts the focus to incumbent firms, examining whether established companies can develop and leverage scalability. We empirically test and extend a recently proposed four-stage model comprising value recognition, organisational adaptation, strategic renewal, and scalability. Using survey data from over 500 Spanish firms, we employ structural equation modelling and causal inference via Python's DoWhy library. Whilst our findings largely align with the four-stage model, some nuances emerge. We find that strategic renewal partially mediates the relationship between organisational adaptation and scalability. We also find that firm size strengthens the mediating role of renewal, while lower technological intensity diminishes it, highlighting conditions under which scalability is more likely to emerge. These findings advance understanding of scalability in established firms and provide practical guidance for managers and policymakers seeking to foster hypergrowth.

## 1. Introduction

In recent years, scalability has attracted growing interest among academics and practitioners (Belitski et al., 2023; Coviello et al., 2024; Martin et al., 2023; Stampfl et al., 2013). The term refers to the capabilities that enable firms to prepare for hypergrowth, whether or not that growth ultimately materialises (Giustiziero et al., 2023; Norbäck et al., 2025). This potential is particularly important for mature corporations, where growth often stagnates (Jansen et al., 2023). Established companies, often constrained by legacy systems and entrenched routines, face particular challenges in adapting to rapid technological and market changes (Vendrell-Herrero et al., 2025). For these firms, scalability is central to sustained competitiveness. Policymakers also have a strong interest in fostering growth in incumbents because it can deliver significant economic benefits, including increased employment, tax revenues, and global market competitiveness (Criscuolo et al., 2012).

Vendrell-Herrero et al. (2025) recently proposed a four-stage model

in which value recognition, organisational adaptation, and strategic renewal precede and enable scalability. Drawing on an in-depth case study of Nvidia, they show that these four phases can indeed be applied to a real-world context. However, while this provides valuable theoretical insight (Ruef & Birkhead, 2024), the model is derived from a single, technologically advanced firm, and its broader applicability to more traditional low-tech industries remains uncertain.

Responding to calls for empirical validation across different industries and geographies (Giustiziero et al., 2023; Jansen et al., 2023), the present study translates the proposed model into measurable constructs and tests it using a dataset of over 500 Spanish manufacturing and service firms. We apply covariance-based Structural Equation Modelling (SEM) and the DoWhy framework to explore the relationships and pathways implied by the original model. By focusing on firms with moderate annual growth (10% or more), we conceptualise scalability as a capability rather than realised hypergrowth.

Our findings yield meaningful theoretical contributions by providing

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partial support for the model. As such, we address the “theory crisis” in management research (Cronin et al., 2021) and illustrate how validation—whether partial or full—strengthens empirical grounding, generalisability, and practical relevance. Although such practices are common in the natural sciences, they remain relatively rare in management research.<sup>1</sup> Nevertheless, empirical testing is essential for connecting theories to practice rather than being mere exercises in abstraction. Our investigation substantiates the model's theoretical underpinnings while offering practical implications for managers. We thus contribute to cumulative theory development and show how evidence-based validation can strengthen the robustness and applicability of management frameworks (Vaillant et al., 2025a).

We also extend the four-stage scalability model by examining its boundary conditions, specifically whether its applicability is confined to high-technology settings or extends to low-tech industries. While the model demonstrates robustness across industries, its effects are stronger in high-technology contexts. These findings provide actionable insights for organisations seeking long-term sustainability and performance in dynamic industrial environments.

## 2. Background literature

### 2.1. Scale up, Scaling, and scalability

Scalability refers to a firm's ability to meet its value-creation and value-capture goals as its customer base expands and needs evolve (Stampfl et al., 2013). Coviello et al. (2024, p.2) define it as “an organizational capability achieved by aligning a firm's technological architecture, organizational architecture, and business model.” To avoid confusion, scalability as a capability must be distinguished from scaling as a process and from the scale-up phase of organisational growth. In short, scalability denotes the potential to grow efficiently, scaling refers to managerial actions that expand outputs without proportionally increasing inputs, and scale-up describes the stage in which firms actively apply scaling and achieve hypergrowth.

Jansen et al. (2023) distinguish between start-ups that reach hypergrowth—labelled “scale-ups”—and incumbents that do so—termed “superstars.” The former are rare, yet they outnumber the latter. Spotify and Airbnb are examples of scale-ups whose business models enabled rapid expansion without the structural and strategic constraints typical of established firms—such as legacy systems, parallel business units, and entrenched routines—that make reproducing start-up-like scalability complex and uncertain.

### 2.2. The sequential model of scalability for incumbent firms

Although hypergrowth is more commonly associated with start-ups, Nvidia is a rare exception. Between 2022 and 2024, this ‘superstar’ incumbent (Jansen et al., 2023), founded in 1993 and already three decades old, experienced exceptionally high growth, becoming the most valuable publicly traded company in the world. Vendrell-Herrero et al. (2025) argue that Nvidia's trajectory illustrates how incumbents can indeed develop scalability. Their central question concerns how incumbents can build scalability when they encounter new opportunities. While start-ups may move directly from recognition to scalability, incumbents face additional constraints stemming from legacy systems and parallel units.

Using periodisation and narrative-based techniques (Rowlinson et al., 2014), scholars can identify endogenous strategic choices and

<sup>1</sup> Some well-known exceptions include Miller and Chen (2004), who largely rejected the highly cited model of organisational risk in decision-making developed by March and Shapira (1987), and Panagopoulos et al. (2017), who partially validated but also extended the model of Tuli et al. (2007) on solution selling in buyer-seller relationships.

exogenous market conditions that shape organisational change (Argyres et al., 2020). Vendrell-Herrero et al. (2025) propose two key transitions from opportunity recognition to scalability: organisational adaptation and strategic renewal, in that order. These concepts are developed further in the hypotheses section. Here, we briefly outline the model.

As shown in Fig. 1, incumbents must first recognise opportunities within evolving value systems, thereby enabling timely adaptation. This ‘discovery phase’ involves realigning competencies and structures in response to technological and market shifts. The subsequent ‘development phase’ centres on strategic renewal, requiring resource reconfiguration and the overcoming of inertia to establish scalable business models. Finally, the exploitation phase aligns strategic flexibility with growth potential by embedding scalable models supported by customer engagement, network effects, and modular governance. This alignment enhances agility, market positioning, and technological inter-relatedness—factors critical for sustained scale-up. Overall, scalability depends on recognising opportunities, adapting organisationally, and renewing strategically, thereby positioning firms for potential hypergrowth. In the following section, we develop hypotheses to test the predictions of Vendrell-Herrero et al. (2025) and examine relevant boundary conditions.

## 3. Hypotheses development

### 3.1. Adaptation as a bridge between opportunity and renewal

Miles et al. (1978) argue that organisational adaptation is triggered by the recognition of strategic value, while Jacobides et al. (2015) contend that such adaptation lays the groundwork for strategic renewal. Building on these perspectives, we propose that organisational adaptation operates as an intermediary between recognising strategic opportunities and implementing renewal.

Strategy and structure are deeply intertwined (Bustinza et al., 2019; Furnari et al., 2021). Strategic priorities shape resource allocation, hierarchies, and decision-making flows (Bowman & Ambrosini, 1997). Structure is therefore responsive—formed by strategic intent and realigned as markets shift (Vaillant et al., 2025b). The ability to restructure quickly supports strategic responsiveness (Gligor et al., 2016), while boundary design shows how such adjustments enhance competitive positioning (Billinger, 2007). Furthermore, adaptive designs characterised by flexibility and decentralisation enable firms to adjust to evolving goals in volatile environments (Bustinza et al., 2019; Gligor et al., 2016), bridging the gap between strategy formulation and execution (Jacobides & Billinger, 2006).

Structure also enables strategic renewal (Agarwal & Helfat, 2009; Kearney & Morris, 2015). Whether through innovation, business model evolution, or partnerships, renewal depends on mechanisms embedded in the organisation's architecture (Vaillant et al., 2025b; Vendrell-Herrero et al., 2021). A well-designed structure fosters learning, experimentation, and integration of new strategic directions (Kirtley & O'Mahony, 2023), helping firms to stay aligned with external change and internal capabilities (Vaillant et al., 2025b). Hence, renewal is part of a continuous cycle in which structure both supports and is reshaped by change. Firms that manage this cycle are better positioned to embed renewal into their core operations, ensuring sustained alignment between goals and capabilities (Vendrell-Herrero et al., 2025). This leads to the following hypothesis:

**Hypothesis 1.** *Organisational adaptation mediates the relationship between strategic value recognition and strategic renewal.*

### 3.2. Renewal as a bridge between adaptation and scalability

Renewal involves rejuvenating organisational capabilities and resources to align with changing market conditions and consumer preferences (Vaillant et al., 2025b), and hence plays an important role in

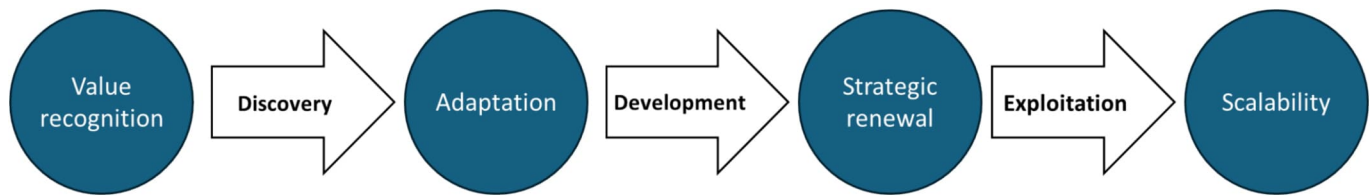


Fig. 1. The Scalability Developmental Stage Model for Incumbent Firms. Note: Adapted from Vendrell-Herrero et al. (2025)

shaping scalability (Vendrell-Herrero et al., 2025). In contrast, adaptation refers to an organisation's capacity to modify its strategies and operations in response to external changes (Andries & Debackere, 2007; Giustiziero et al., 2023). Adaptation therefore requires ongoing capability development and the synchronisation of resources to extract maximum value from scalable assets. Renewal thus becomes indispensable, as scalability involves not only expansion but also the bundling and orchestration of resources to deliver greater value at scale (Jansen et al., 2023). As firms adapt their business models to internal and external shifts, they must also renew their capabilities to support sustainable growth (Vendrell-Herrero et al., 2022). This is particularly the case among born-digital firms (Mihailova, 2023).

Regarding the need to succeed in diverse geographic and institutional environments (Jacobides & Billinger, 2006), Reuber et al. (2021) note that global scaling involves a logic of multinationalisation that hinges on an organisation's capacity to renew its value propositions in different markets (Vendrell-Herrero et al., 2021).

Scaling is rarely linear. It often involves a learning curve as firms experiment with various strategies to determine which are most conducive to long-term viability. Tidhar et al. (2024) note how firms deliberately focus on unit-level profitability, ensuring that their internal structures and processes are robust and aligned before contemplating broader growth. Renewal thus enables organisations to refine strategies and capabilities to enhance coordination and execution. Rather than mere reacting to change, it proactively positions firms for growth (Vendrell-Herrero et al., 2025). Research on divergent scaling strategies shows that different configurations can yield heterogeneous outcomes (Piaskowska et al., 2021), underscoring the context-dependent nature of renewal. By reassessing their adaptive capacities in dynamic markets, firms can develop tailored scaling approaches that strengthen the link between adaptation and scalable growth.

Taken together, the evidence suggests that renewal is the bridge linking adaptation to scalability, implying that firms need to respond to immediate challenges while also regenerating capabilities to sustain

competitiveness in evolving environments (Amankwah-Amoah et al., 2017; Vendrell-Herrero et al., 2022). The interplay between adaptation, renewal, and scalability represents a cycle of performance enhancement (Kearney & Morris, 2015) in which adaptation supports responsiveness, renewal revitalises strategic and operational models (Vaillant et al., 2025b), and scalability delivers long-term growth (Vendrell-Herrero et al., 2025). Accordingly, we propose the following hypothesis:

**Hypothesis 2.** Strategic renewal mediates the relationship between adaptation and scalability.

3.3. The full sequential pathway: From opportunity to scalability

A multi-mediation model is outlined as a plausible causal pathway (Fig. 2). The framework suggests that recognising opportunities within value systems strengthens adaptability, which in turn drives renewal and ultimately scalability.

Strategic renewal is catalysed by adaptation (Mihailova, 2023), and value recognition underpins that capacity (Bretas et al., 2025; Jacobides et al., 2015). By understanding value systems, firms can assess their position relative to evolving demands and realign operational and strategic frameworks accordingly (Giustiziero et al., 2022). These adjustments enable experimentation and innovation, which over time may lead to expansion into new markets or business model transformation (Reuber et al., 2021).

These considerations imply the following sequential pathway: Value Recognition → Organisational Adaptation → Strategic Renewal → Scalability. This interpretation makes explicit assumptions about relationships between variables (Vonk et al., 2023) and potential founders—such as long-term resource allocation and decision-making dynamics (Jansen et al., 2023). Accordingly, we adopt an integrative perspective that bridges theoretical insights (Vendrell-Herrero et al., 2025) with methodological tools for pathway identification and confounder analysis (Molak, 2023), yielding a framework that is both

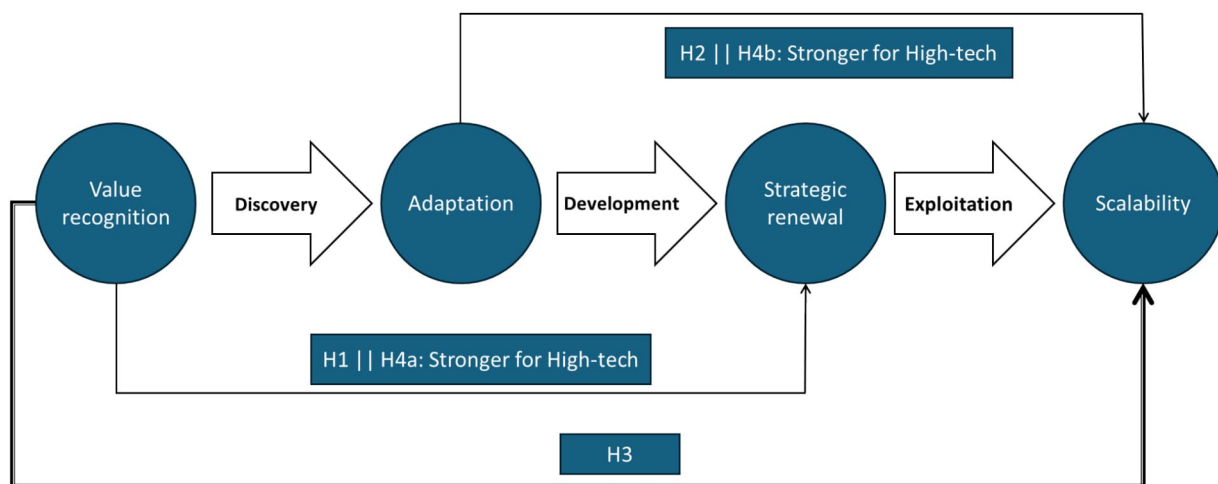


Fig. 2. Designing an Empirical Test of the Scalability Model Considering Technology Intensity. Note: The hypotheses presented here correspond to the pathways being tested, not direct effects. H1 and H2 assess the full mediation effects of adaptation and strategic renewal, respectively. H4a and H4b test whether those mediation effects are stronger in high-technology industries. H3 tests the entire configurational pathway.

conceptually rigorous and empirically testable:

**Hypothesis 3.** *Value recognition influences scalability indirectly through a sequential multi-mediation path: value recognition → organisational adaptation → strategic renewal → scalability. This causal interpretation assumes the absence of unmeasured confounders affecting the relationships between each pair of consecutive variables.*

3.4. Moderating role of industry technology intensity

Giustiziero et al. (2022) argue that higher levels of digital technology increase the likelihood of scalable resource bundles, lower distribution costs, and strong network effects. These conditions affect the opportunity costs of integration by requiring resources to be allocated across multiple value-adding activities rather than concentrated on a single growth domain. Technological intensity is therefore a key driver of scalability and its preconditions (Stampfl et al., 2013). New technologies reduce communication costs (Rappa, 2004), enable novel interactions (Bouwman & MacInnes, 2006), facilitate innovative transactions (Amit & Zott, 2001), and accelerate environmental change (Stampfl et al., 2013). Together, these dynamics make scaling more feasible, particularly in high-technology industries, where disruption demands agility (Abdalla et al., 2025; Ameen & Tarba, 2025) and amplifies the importance of dynamic capabilities (Rigby et al., 2016).

Digital adoption also reduces demand constraints, allowing firms to expand output while remaining specialised (Giustiziero et al., 2022). Nvidia’s trajectory (Vendrell-Herrero et al., 2025) illustrates how incumbents in high-tech contexts can achieve scalability by leveraging these conditions. In such settings, product modularity—enabled by technological complexity and interdependence—further supports growth by facilitating parallel development, upgrades, and customisation (Salvador, 2007). This modularity enhances adaptation, supports renewal, and strengthens scalability while maintaining coherence across technological, organisational, and business model architectures (Sanchez & Mahoney, 1996).

Overall, higher technological intensity is likely to strengthen the mediation effects outlined in H1 and H2. Accordingly, we propose the following hypotheses:

**Hypothesis 4a.** *(Technology intensity moderates the mediation effect of organisational adaptation on the relationship between strategic value recognition and strategic renewal)* **Hypothesis 4b.** *Technology intensity moderates the mediation effect of strategic renewal on the relationship between organisational adaptation and scalability.*

4. Method

4.1. Methodological approach

We now test the Vendrell-Herrero et al. (2025, p. 12) model using a broader sample of established firms, following the authors’ recommendation to use “mediation analysis—for example, examining Organizational Adaptation as a mediator between Value System Recognition and Strategic Renewal, and Strategic Renewal as a mediator between Adaptation and Scalability” and suggestion that “path dependency analysis may offer valuable insights.” We do so by implementing inference through modeling, identification, estimation, and refutation (Molok, 2023).

The empirical model in Fig. 2 combines mediation and path analysis. Although Ordinary Least Squares (OLS) regression is the most common method for associational analysis (Bustinza et al., 2024), Structural Equation Modelling (SEM) is preferable when constructs are measured indirectly and mediation effects are explored (Hair et al., 2020). SEM is particularly suitable for examining theoretical constructs—such as capabilities—that cannot be directly measured. Capabilities develop over time through pathways that align resources and competencies (Laamanen & Wallin, 2009), but they are often assessed cross-sectionally (Wilden et al., 2013). Mediation analysis can therefore be

used to explore underlying relationships by modeling how intermediaries may affect outcomes (Kline, 2023). In this study, scalability is treated as a latent variable measured through multiple items, with the pathway to scalability described by interrelated mediators.

The model proposes two mediation relationships: (a) organisational adaptation mediates the relationship between value recognition and strategic renewal (H1), and (b) strategic renewal mediates the relationship between organisational adaptation and scalability (H2). If both relationships are confirmed, this suggests the presence of two unconnected paths. To establish an overarching pathway linking these stages, Fig. 2 incorporates a path analysis (H3).

We examine this pathway using the DoWhy library in Python, which encodes assumptions in a directed acyclic graph and estimates effects using backdoor or front-door adjustments (Molok, 2023). These methods assume (i) that the graph correctly represents the data-generating process, (ii) that all relevant confounders are observed and adjusted for (backdoor), or that the mediators fully intercept causal paths (front-door), and (iii) that the statistical models are correctly specified. While DoWhy enhances transparency through explicit assumptions and refutation tests, its validity depends on the accuracy of the graph and the absence of unobserved confounding.

4.2. Data

Following the proposal of Vendrell-Herrero et al. (2025, p. 12), we study a sample of incumbent Spanish firms exhibiting both moderate and high growth.

Financial data for manufacturing and service firms with over 10 employees was sourced from the ORBIS database (Bureau Van Dijk, BvD). Firms were selected based on employment growth, non-increasing marginal costs, and an expanding customer base, resulting in 2,040 eligible firms.

After a pilot survey with three managers, the questionnaire was further refined by a market research firm, which conducted Computer-Assisted Telephone Interviews (CATI), a reliable, cost-effective method that is commonly used in behavioural studies (Couper, 2000; Opazo-Basáez et al., 2022).

Between September and October 2021, firms were contacted, with each interview lasting approximately 20 min. A Gaussian distribution with a 99% confidence level indicated a minimum sample of 501 firms, which we surpassed by collecting 509 valid responses. All respondents held top managerial positions focused on technology, operations, and sales (see Table 1).

As shown in Table 2, 181 firms operate in manufacturing and 328 in services, with the latter further divided into professional, technological, and administrative services (107) and other services (221 firms). Small enterprises (10 to 49 employees) account for 78.39%, medium-sized (50 to 249 employees) for 17.49%, and large (250 to 999) and very large enterprises (over 1,000) for only 3.14% and 0.98%, respectively.

To assess non-response bias, early and late respondents were compared using t-tests following Armstrong and Overton (1977), with no statistically significant differences at the 99% confidence level. To control for common method bias (CMB), survey responses were combined with ORBIS financial information, including the metrics used to classify firms’ scalability. Industry characteristics were also included as

**Table 1**  
Respondent Positions and Business Functions.

Position	Frequency	%	Business Function	Frequency	%
Executive Level	49	9.63%	Sales & Marketing	147	28.88%
Vice President	111	21.81%	Technology & Engineering	249	48.91%
Director	349	68.56%	Operations	113	22.21%

**Table 2**  
Distribution of Sample by Industry and Size.

		Full Sample	Manufacturing All	Services Professional, technological and administrative services	Other services
FREQ.	Observations	509	181	107	221
NAICS	Industry classification	All	31—33	51—56	11, 21–23, 61–81
SIZE	Small enterprises (from 10 to 49 employees)	399 (78.39%)	150 (82.87%)	70 (65.42%)	179 (81.00%)
	Medium-sized enterprises (from 50 to 249)	89 (17.49%)	28 (15.47%)	31 (28.97%)	30 (13.57%)
	Large enterprises (from 250 to 999 employees)	16 (3.14%)	3 (1.66%)	6 (5.61%)	7 (3.17%)
	Very large enterprises (more than 1,000 employees)	5 (0.98%)	0 (0.00%)	0 (0.00%)	5 (2.26%)

moderating variables, extending beyond respondents' cognitive framework (Chang et al., 2010).

#### 4.3. Variables and Justification

We now discuss the four key constructs. The items and reliability analyses for all scales are presented in Table 3. All items were rated on a 7-point Likert scale (1 = Total disagreement; 7 = Total agreement).

**Value recognition** (Billinger, 2007; Jacobides & Billinger, 2006) captures characteristics of the value system in which firms operate, such as separability of products and processes that enable unbundling and disintegration, and efforts to benchmark in-house operations to recognise systemic shifts in the industry with potential scale-up opportunities.

**Organisational adaptation** (Jacobides & Billinger, 2006) is measured as a second-order construct reflecting (a) vertically permeable structures arising from adequate internal adjustment mechanisms for future process redesign and pertinent IT structures, and (b) boundary architecture promoting modular products, processes, and technological configurations (Vos et al., 2018).

**Strategic renewal** (Vaillant et al., 2025b) captures flexibility in buying and selling within the value system, offer of new products and solutions, responsiveness, and ability to address specialised needs and provide tailored solutions (Van der Borgh et al., 2023).

**Scalability** (OECD/Eurostat, 2018; Sleuwaegen & Ramboer, 2020) encompasses indicators measuring sales growth, non-increasing marginal costs, customer base expansion, and entry into new market niches.

Discriminant validity between organisational adaptation and strategic renewal was assessed using the Fornell–Larcker criterion. As shown in Table 4, the diagonal values corresponding to the square root of each construct's Average Variance Extracted (AVE) consistently exceed the off-diagonal values that represent the inter-construct correlations. This shows that our constructs capture two distinct conceptual domains, thereby reinforcing the validity of our mediation results.

**Moderators:** Technological intensity is included as a moderating variable that provides a fuller picture of how firms leverage strategic insights and internal adaptation. Industries are classified as high- or low-technology according to the classification proposed by the Spanish National Institute of Statistics (Felipe et al., 2020). In our sample, 192 firms are in high-tech sectors and 317 are in low-tech ones. We examine whether industry-level technology intensity moderates the relationships between value recognition, adaptation, renewal, and scalability.

## 5. Results

### 5.1. Mediation analysis

Our model proposes two mediation relationships, tested in Stata 17 using covariance-based structural equation modelling (CB-SEM), as recommended for testing theoretical relationships (Hair et al., 2011).

a) *Organisational adaptation*, measured as a second-order construct, mediates the relationship between *value recognition* and *strategic renewal*.

The results show a positive and significant influence of *value recognition* on *strategic renewal* ( $\beta_1 = 0.498, p < 0.001$ ), of *organisational adaptation* on *strategic renewal* ( $\beta_2 = 0.484, p < 0.001$ ), and of *organisational adaptation* on *value recognition* and *strategic renewal* ( $\beta_{\text{Total1}} = 0.251, p < 0.001$ ), with the direct effect being almost zero and non-significant ( $\beta_{\text{Direct1}} = 0.015, p = 0.685$ ) and the indirect effect ( $\beta_{\text{Indirect1}} = 0.236, p < 0.001$ ) representing the vast majority of the total ( $0.236/0.251 = 94.02\%$ ). This indicates that the mediator, *organisational adaptation*, is primarily responsible for the influence of *value recognition* on *strategic renewal*. Bootstrapping with 5,000 repetitions confirmed that the 95% Confidence Interval (CI) for the indirect effect did not cross zero (s.e. = 0.015, [0.009:0.068]), supporting Hypothesis 1.

b) As for the relationship between *strategic renewal* and *scalability*, we observe a positive and significant coefficient ( $\beta_3 = 0.469, p < 0.001$ ). The mediation analysis yields a positive and significant total effect of *organisational adaptation* through *strategic renewal* on *scalability* ( $\beta_{\text{Total2}} = 0.421, p < 0.001$ ), the direct effect being significant ( $\beta_{\text{Direct2}} = 0.194, p < 0.05$ ) and the indirect effect ( $\beta_{\text{Indirect2}} = 0.227, p < 0.05$ ) representing 53.92% of the total ( $0.227/0.421$ ). Bootstrapping confirms that the 95% CI for the indirect effect does not cross zero (s.e. = 0.025, [0.018:0.086]), indicating that *strategic renewal* partially mediates the relationship between *organisational adaptation* and *scalability*. These results partially support Hypothesis 2. The parameters and statistical significance are shown in Table 5 and Fig. 3.

To account for potential endogeneity between *value recognition* and *scalability*, we used a Generalised Structural Equation Model (GSEM) with covariance restrictions between structural disturbances and an instrumental variable. This accounts for unobserved confounding by setting the covariances between structural error terms to zero, under the assumption that endogeneity arises from omitted variables that induce correlated errors between endogenous predictors and outcomes. Specifically, we introduce *Sensors* as an instrumental variable for *value recognition*, based on its theoretical and empirical relevance (Porter & Heppelmann, 2014). Sensor-based data collection capabilities are widely viewed as antecedents that enable firms to detect and interpret external opportunities, while being plausibly exogenous to *value recognition*. *Sensors* are strongly associated with *value recognition* ( $\beta = 0.665, s.e. = 0.148, p < 0.001$ ), justifying their use for addressing endogeneity in the structural path from *value recognition* to downstream organisational outcomes (Fig. 3). This strategy enables more reliable inference within complex path models while mitigating bias from endogeneity.

Additionally, we include the natural logarithm of firm age ( $\ln_{\text{firm\_age}}$ ) to account for potential confounding effects related to organisational characteristics (Benitez et al., 2022). Older firms often employ different routines, resources, and constraints, which may limit scalability, so we isolate the effects of the core theoretical variables and reduce bias from age-related heterogeneity. In the final path of the model (renewal  $\rightarrow$  scalability),  $\ln_{\text{firm\_age}}$  has a statistically significant negative effect ( $\beta = -0.265, SE = 0.093, p = 0.004$ ), suggesting that, within incumbents, older firms may be moderately less likely to scale innovations in response to renewal. This does not preclude scalability,

**Table 3**  
Scales, Factor Loadings and Reliability Analysis.

Construct	Item Description	Item ID	Mean (S. D.)	Factor Loading (t-values)	R <sup>2</sup>	Reliability
<b>VALUE RECOGNITION</b>	Separability of products along the value chain	VSR1	3.931 (2.362)	0.732 (23.06)	0.536	KMO = 0.825, Bartlett's test $\chi^2 = 837.38$ (p = 0.000), TVE = 68.11%, Cronbach's alpha = 0.839, AVE = 0.591, CR = 0.852.
	Separability of processes (organisational unbundling)	VSR2	4.672 (2.227)	0.805 (26.49)	0.648	
	Separability along the value chain (organisational disintegration)	VSR3	4.596 (2.218)	0.794 (26.39)	0.630	
	Regular internal and external benchmarking of in-house operations	VSR4	4.256 (2.115)	0.779 (28.70)	0.607	
<b>ORGANISATIONAL ADAPTATION</b> <i>Vertically permeable structures</i>	Business planning	ADS1	5.239 (1.841)	0.716 (30.92)	0.513	KMO = 0.874, Bartlett's test $\chi^2 = 1744.37$ (p = 0.000), TVE = 59.03%, Cronbach's alpha = 0.855, AVE = 0.537, CR = 0.862.
	Process redesign	ADS2	4.920 (2.010)	0.805 (30.68)	0.648	
	IT structure	ADS3	5.290 (1.829)	0.749 (31.12)	0.561	
	Modular products	ADS4	4.840 (2.121)	0.769 (30.42)	0.591	
	Modular processes	ADS5	4.878 (2.143)	0.751 (28.69)	0.564	
	Technological components	ADS6	4.789 (2.196)	0.707 (30.23)	0.500	
<b>ORGANISATIONAL ADAPTATION</b> <i>Firm boundary architecture</i>	Modular process redesign	ADA1	4.417 (2.071)	0.830 (26.63)	0.689	KMO = 0.852, Bartlett's test $\chi^2 = 2228.38$ (p = 0.000), TVE = 67.28%, Cronbach's alpha = 0.851, AVE = 0.632, CR = 0.867
	Architectural technology	ADA2	4.369 (2.140)	0.822 (26.26)	0.676	
	Reconfigurability of modular structures	ADA3	4.542 (2.059)	0.864 (26.89)	0.746	
	Creation of distinct capability bundles	ADA4	4.548 (2.020)	0.827 (27.22)	0.684	
<b>STRATEGIC RENEWAL</b>	Flexible buying & selling along the value chain	STR1	4.583 (2.551)	0.843 (29.20)	0.711	KMO = 0.812, Bartlett's test $\chi^2 = 1287.38$ (p = 0.000), TVE = 66.56%, Cronbach's alpha = 0.795, AVE = 0.598, CR = 0.800
	New product & solution offerings	STR2	4.862 (2.345)	0.819 (29.93)	0.671	
	Greater responsiveness	STR3	4.580 (2.224)	0.804 (30.04)	0.646	
	Addressing specialised needs	STR4	4.807 (2.117)	0.747 (30.19)	0.558	
	Offering complete/tailored solutions	STR5	4.385 (2.219)	0.745 (30.06)	0.555	
<b>SCALABILITY</b>	High sales growth	SCA1	4.598 (2.363)	0.764 (29.45)	0.584	KMO = 0.811, Bartlett's test $\chi^2 = 854.93$ (p = 0.000), TVE = 68.97%, Cronbach's alpha = 0.789, AVE = 0.588, CR = 0.850
	Non-increasing marginal costs	SCA2	4.039 (2.354)	0.787 (28.97)	0.619	
	Increased customer base	SCA3	4.573 (2.305)	0.730 (29.58)	0.533	
	Reaching blue ocean niches	SCA4	4.041 (2.488)	0.782 (28.55)	0.616	

**Table 4**  
Discriminant Validity.

	Fornell-Larcker Criterion			
	Value recognition	Organisational adaptation	Strategic renewal	Scalability
Value recognition	0.769			
Organisational adaptation	0.535	0.733		
Strategic renewal	0.258	0.575	0.702	
Scalability	0.270	0.579	0.478	0.767

but indicates certain constraints, likely due to more rigid structures or path-dependent practices.

Overall, the model presents suitable indicators of absolute and incremental goodness of fit (Hair et al., 2018): Chi-square likelihood ( $\chi^2 = 635.674$ , p = 0.063), GFI = 0.925 > 0.900, RMSEA = 0.061, between 0.050 and 0.080, RMR = 0.039 < 0.050, CFI = 0.951 > 0.900 and TLI = 0.947 > 0.900.

### 5.2. Path analysis

Fig. 3 illustrates two sequential mediation effects: (1) *value recognition* influences *strategic renewal* through *organisational adaptation*, and (2) *organisational adaptation* affects *scalability* via *strategic renewal*. Together, these create a total path from *value system recognition* to *scalability*, mediated first by *organisational adaptation* and then by *strategic renewal*. This constitutes a multi-step mediation model in SEM, where each mediator transmits part of the effect in sequence. The total effect from *value recognition* to *scalability* is the product of these effects. However, we rely on the DoWhy framework to analyse the entire pathway, as this emphasises explicit specification of causal assumptions, whereas SEM often relies on assumptions within the model specification. DoWhy also provides refutation tests to assess robustness against unobserved confounders (Molak, 2023).

The DoWhy framework consists of four steps that we use to test Hypothesis 3. We introduced an unobserved confounder affecting both *value recognition* and *scalability*, modelled as independently distributed noise. In the second step, we tested three estimands and identified front-door as the correct one. This estimand employs a divide-and-conquer strategy, analysing the effects along sub-paths and before combining

**Table 5**  
Mediation Analysis and Bootstrap Results.

Analysis	Beta	se	t	p
<b>Hypothesis 1 &amp; 2 Direct Effects:</b>				
Value Sys. Rec. → Org. Adaptation	0.498***	0.049	5.045	<0.001
Value Sys. Rec. → Stra. Renewal	0.015	0.063	6.111	=0.685
Org. Adaptation → Stra. Renewal	0.484***	0.079	6.741	<0.001
Org. Adaptation → Scalability	0.194**	0.066	5.988	<0.01
Stra. Renewal → Scalability	0.469***	0.059	5.193	<0.001
<b>Hypothesis 1 &amp; 2 Indirect Effects:</b>				
Bootstrap result for indirect effect				
I. Effect	Se	LL 95%	UL 95%	
		CI	CI	
Value Sys. Rec. → Org. Adaptation x Org. Adaptation → Stra. Renewal	0.236***	0.015	0.01	0.07
Org. Adaptation → Stra. Renewal x Stra. Renewal → Scalability	0.227***	0.026	0.02	0.09
<b>Hypothesis 1 &amp; 2 Total Effects:</b>				
Value Sys. Rec. → Org. Adaptation → Stra. Renewal	0.251***	0.051	6.138	<0.001
Org. Adaptation → Stra. Renewal → Scalability	0.421***	0.055	5.227	<0.001
<b>Path analysis DoWhy</b>				
		Refutation test (80% of the sample)		
Value Sys. Rec → Org. Adaptation → Stra. Renewal → Scalability	0.207	0.209 (p-value = 0.98)		

Note: \*p < 0.05, \*\*p < 0.01, \*\*\*p < 0.001.

them to estimate the overall effect across the sequential pathway (value recognition → organisational adaptation → strategic renewal → scalability). In the third step, we estimated an Average Treatment Effect (ATE) of 0.207. In the final step, we validated the result through a refutation test that randomly excluded a portion of the data and recalculated the causal effect. A data subset refutation (data\_subset\_refuter) using 80% of the original data yielded a ‘New Effect’ of 0.209 (p = 0.98). The estimate appears at the bottom of Table 5.

The absence of a statistically significant difference between the full-sample ATE (0.207) and the subsample estimate (0.209) indicates that the causal effect is stable and not driven by sample variation. The consistency of these estimates provides robust evidence of a causal effect of value recognition on scalability transmitted through organisational adaptation and strategic renewal. This is consistent with our proposed explanatory multi-mediation pathway, thereby supporting Hypothesis 3.

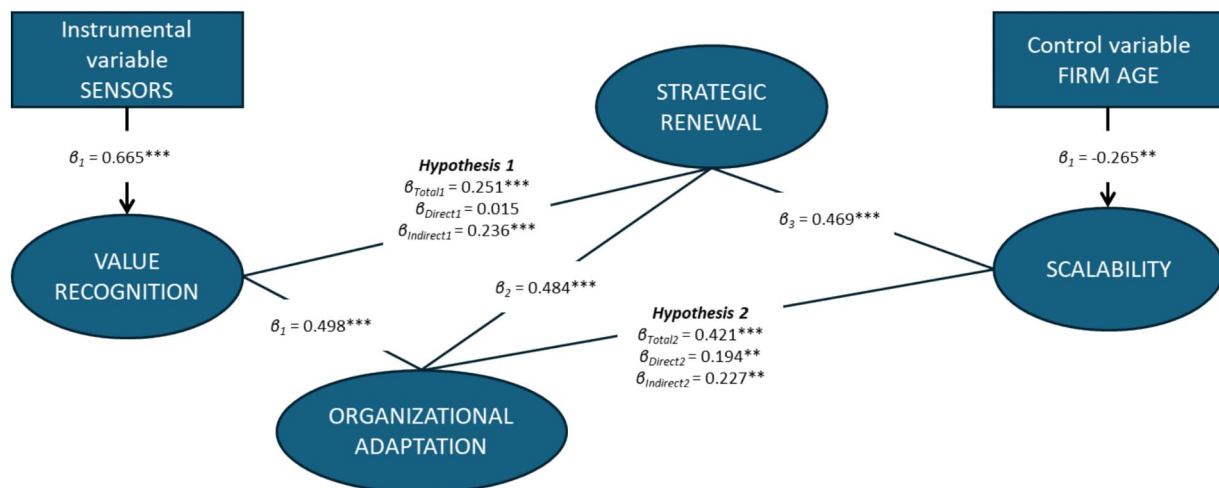
**Table 6**  
Industry Technological Level Moderation Using Subsamples.

Analysis	Full sample (n = 509)	High Technology intensity (n <sub>1</sub> = 192)	Low Technology intensity (n <sub>2</sub> = 317)
<b>Hypothesis 1 Direct Effects:</b>			
Value Sys. Rec. → Stra. Renewal	0.015 (5.98% D. effect)	0.009 (3.42% D. effect)	0.02 (8.30% D. effect)
<b>Hypothesis 1 Indirect Effects:</b>			
Value Sys. Rec. → Org. Adaptation x Org. Adaptation → Stra. Renewal	0.236*** (94.02% I. effect)	0.254*** (96.58% I. effect)	0.221*** (91.70% I. effect)
<b>Hypothesis 1 Total Effects:</b>			
Value Sys. Rec. → Org. Adaptation → Stra. Renewal	0.251***	0.263***	0.241***
<b>Hypothesis 2 Direct Effects:</b>			
Org. Adaptation → Stra. Renewal	0.194** (46.08% D. effect)	0.181*** (37.24% D. effect)	0.2055** (53.09% D. effect)
<b>Hypothesis 2 Indirect Effects:</b>			
Org. Adaptation → Stra. Renewal x Stra. Renewal → Scalability	0.227*** (53.92% I. effect)	0.305*** (62.76% I. effect)	0.182*** (46.91% I. effect)
<b>Hypothesis 2 Total Effects:</b>			
Org. Adaptation → Stra. Renewal → Scalability	0.421***	0.486***	0.387***

Note: \*p < 0.05, \*\*p < 0.01, \*\*\*p < 0.001.

5.3. Moderation analysis

We performed a moderation analysis with sectoral technology intensity as a pure moderator; that is, it does not directly affect the dependent variable but alters the strength of the paths (Sharma et al., 1981). Using a median-split multi-group approach, we compared high and low technology sectors. We then restricted the paths to equality and compared the solution to that of the unconstrained model using a  $\chi^2$  difference test (Byrne, 2013). As we found significant increases in  $\chi^2$  when analysing the restricted model ( $\chi^2 = 876.679$  vs  $\chi^2 = 622.433$ ), we classified technology intensity as a moderator. Free estimation found increases in all parameters in the high technology subsample. Although both mediation effects remain qualitatively unchanged after including



**Fig. 3.** Structural Equation Model Results. Note: The parameters reported correspond to the tests of Hypotheses 1 and 2 within a combined model that includes both instrumental and control variables. Key parameters are also presented in Table 5 alongside the DoWhy parameters for Hypothesis 3. Tests examining the boundary condition of technology intensity are reported in Table 6. Levels of statistical significance: \*p<0.05, \*\*p<0.01, \*\*\*p<0.001.

the instrument and control variable (i.e., total for [Hypothesis 1](#) and partial for [Hypothesis 2](#)), the percentage of the indirect effect is higher for high-tech firms in both hypotheses (see [Table 6](#)). The change in H2 is noteworthy, as the indirect pathway appears stronger in more technologically advanced settings. For example, the indirect effect increased from 47% (low-tech) to 63% (high-tech), a difference of 16 percentage points. These findings support [Hypotheses 4a](#) and [4b](#), indicating that higher technological intensity strengthens the mediation effects.

## 6. Extending the model

Programmatic theory treats conceptual models as starting points for iterative testing and refinement using diverse empirical methods ([Cronin et al., 2021](#)), enabling closer approximation of real-world dynamics. This aligns with calls by [Jansen et al. \(2023\)](#) and [Giustiziero et al. \(2023\)](#) for cumulative theorising in scale-up/scalability research. While our primary aim was to test the model proposed by [Vendrell-Herrero et al. \(2025\)](#), we incorporated built-in extensions, most notably the boundary condition of technological intensity. This reflects prior theorisation that industry technology shapes adaptation and renewal mechanisms (e.g., [Amit & Zott, 2001](#); [Giustiziero et al., 2022](#); [Sanchez & Mahoney, 1996](#)), suggesting that scaling dynamics may vary with sectoral modularity and innovation regimes.

By generalising beyond the original single-case approach—focused on an extreme firm with the world’s largest capitalisation, rapid scale-up trajectories, and advanced technological sophistication—to a broader sample of smaller incumbent firms with moderate growth and varying technological intensity, we capture additional contextual influences<sup>2</sup> on scalability, particularly firm size and technology. Moreover, while [Hypothesis 1](#) shows full mediation, [Hypothesis 2](#) shows only partial mediation: adaptation can influence scalability directly, suggesting that renewal may function less as a strict intermediary. This resonates with [Jacobides and Billinger \(2006\)](#) and [Bowman and Ambrosini \(1997\)](#), who noted that structural adaptation can yield performance gains independently of broader renewal, particularly when boundary reconfigurations or process optimisations directly enhance scalability.

This broader context, combined with the mediation tests, largely confirms the model’s core propositions, including the centrality of value recognition, adaptation, and renewal, while revealing refinements to the predicted relationships. These insights extend the original model, highlighting areas of alignment and those requiring refinement. We summarise these extensions in [Table 7](#).

Value recognition emerges as a consistent antecedent to scalability. Conceptual and empirical evidence confirm that without recognising new growth opportunities, scalability is unlikely to emerge. Adaptation remains a central driver, enabling growth and renewal; however, for smaller firms, it can also influence scalability directly, partially decoupling the theorised mediation via renewal. For example, a small manufacturing firm in a low-tech sector may adopt process improvements that immediately improve scalability without necessarily undergoing formal renewal. In contrast, a large high-tech firm, such as a semiconductor producer, may require extensive renewal—restructuring teams, developing capabilities, or launching innovations—to translate adaptation into scalable growth.

Renewal, while originally proposed as the principal mechanism underpinning scalability, empirically functions more as an independent outcome that only partially contributes to scalability. This pattern is especially evident in low-tech firms, where stronger direct effects reduce the relative explanatory role of renewal as a mediating mechanism. This aligns with [Kearney and Morris \(2015\)](#) and [Agarwal and Helfat \(2009\)](#), who conceptualise renewal as a dynamic capability contingent on

organisational and environmental conditions rather than a universally mediating process. For instance, a low-tech service firm may implement renewal initiatives—such as updating IT systems or redesigning workflows—that enhance organisational learning and performance but do not directly drive new growth. Conversely, in high-tech contexts, renewal is more tightly coupled with scalability because technological innovations directly expand market opportunities.

To further clarify these dynamics, and assuming full mediation effects through renewal in the Nvidia case used for the original model, we isolate the contributions of firm size and technological intensity to partial mediation. Comparing Nvidia with high-tech firms, we observe a substantial decrease in mediation (100% → 62%, a 38% reduction), reflecting the effect of firm size. Examining the effect of technology by comparing high-tech and low-tech firms, mediation also decreases, albeit less dramatically (62% → 47%, a 24% reduction). Regardless of which effect is more pronounced, these boundary conditions indicate that scale amplifies the relevance of renewal, while lower technological intensity weakens its mediating effect. In practice, smaller firms can achieve scalability by adapting core processes, whereas global high-tech firms require deliberate renewal to fully leverage adaptation for scalability.

## 7. Discussion

### 7.1. Academic implications

This study advances understanding of scalability in established firms by empirically testing and partially validating the [Vendrell-Herrero et al. \(2025\)](#) model. While originally developed using the high-profile example of Nvidia, our research applies it to firms experiencing nascent or moderate growth, extending its relevance beyond exceptional cases to more conventional contexts. In doing so, it responds to the “theory crisis” in management research ([Cronin et al., 2021](#)) by demonstrating how rigorous validation can strengthen theoretical foundations and offer extensions.

A key contribution lies in demonstrating mediation effects and path analysis supporting the theorised sequence. We find that established firms can develop hypergrowth capabilities, but unlike start-ups, opportunities alone are insufficient. Firms must engage in deliberate adaptation and renewal to fully activate scalability potential. This adds to literature on dynamic capabilities and strategic change ([Laamanen & Wallin, 2009](#); [Wilden et al., 2013](#)) by showing that value recognition ([Jacobides & Billinger, 2006](#)), organisational flexibility ([Mihailova, 2023](#)), and renewal ([Vaillant et al., 2025b](#)) must co-evolve to support sustained growth.

Our study not only translates Vendrell-Herrero’s four-stage model into measurable constructs and tests it empirically, but also extends this framework. While [Hypothesis 1](#) shows full mediation, [Hypothesis 2](#) shows partial mediation, suggesting certain associated factors are not captured. The original Nvidia case was driven by the technological intensity of the semiconductor industry, and our findings indicate stronger mediation in similar high-tech industries. Although the model is applicable across industries, factors such as greater disruption—which creates growth opportunities—and digitalisation, which enhances adaptability, reduces marginal costs, and improves replicability, may partially explain the model’s stronger performance in tech-intensive contexts. Future research should explore other contextual conditions to clarify where the model performs best.

Methodologically, the study contributes by applying the Python library DoWhy to address a persistent limitation in organisational research—the lack of longitudinal data to establish temporal causality. Using this framework ([Molak, 2023](#)), we detect and validate hypothesised pathways even in the absence of traditional time-series data, offering a robust alternative for testing theoretical models under data constraints. To our knowledge, no prior business study has employed this methodology. Its introduction is therefore significant, particularly

<sup>2</sup> See [Avgerou \(2019\)](#) for a discussion of how providing contextual explanations contributes to further development and refinement of theoretical frameworks.

**Table 7**  
Comparison Between Conceptual and Empirical Studies on Firm Scalability.

Dimension	Vendrell-Herrero et al. (2025), Long Range Planning	This Study	Alignment / Difference
<b>Programmatic Theory Development</b>	Inductive conceptual study based on an in-depth single case study.	Generalizable empirical study based on a large-scale quantitative survey.	The two form a perfect conceptual–empirical pair that reinforce and extend one another.
<b>Context</b>	Extreme case in terms of firm size (world's largest capitalisation), exponential growth trajectory (scale-up dynamics), and technological sophistication (advanced semiconductor technologies).	Representative sample of incumbent firms of smaller size, moderate annual growth rates (>10%), and varying levels of technological intensity (high vs. low-tech industries).	Broader and more generalizable empirical context validates the theoretical propositions across diverse conditions.
<b>Role of Recognition</b>	Scalability depends fundamentally on the identification of new opportunities; without value recognition, no scalability path can emerge.	Consistent with the conceptual model: value recognition remains a necessary antecedent to scalability.	The prediction is fully validated.
<b>Role of Adaptation</b>	Adaptations act as a central driver of organisational renewal, enabling adaptive capacity and subsequent growth capabilities.	Adaptations continue to drive renewal and growth but may lead to partially distinct scalability pathways depending on firm characteristics and industry context.	Largely consistent, though for smaller firms' adaptation appears to connect more directly to scalability, without the strict necessary link through renewal.
<b>Role of Renewal</b>	Renewal is theorised as a principal mechanism underpinning firm growth and scalability.	Renewal emerges empirically as a more independent outcome variable that only partially contributes to scalability, especially in low-tech settings.	Empirical evidence refines the theory by indicating that renewal is not uniformly predictive of scalability.
<b>Separate Role of Scale and Technology</b>	The focal firm is large and technologically advanced. These elements seem to magnify the relationships above—more renewal is necessary in larger organisations.	Mediation effects are reduced partly because of firm size (H1: 100% → 96%; H2: 100% → 62%) and partly because of technological intensity (H1: 96% → 91%; H2: 62% → 47%).	The quantitative analysis clarifies that size and technology act as boundary conditions: scale amplifies renewal's relevance, whereas lower technological intensity weakens it.
<b>Change in Theoretical Emphasis</b>	Recognition, adaptation, and renewal jointly constitute the dynamic mechanisms through which firms achieve scalability.	Empirical results suggest a partial decoupling: renewal is an outcome of adaptation but not always a precursor of scalability. This adjustment nuances the original theory by introducing conditional pathways based on technological intensity and firm size.	The quantitative analysis provides a contextual explanation, indicating theoretical refinement rather than contradiction, and extending the programmatic theory toward boundary conditions.

given the large number of process models in organisational research (e.g., see [Aguilar-Savén, 2004](#)) that could benefit from its application.

## 7.2. Managerial implications

Beyond theory, the study offers practical insights for managers. By confirming the generalisability of the framework, we highlight how organisations can position themselves for growth.

In today's digitalised context, size and age may matter less than agility and responsiveness to change. Firms that adapt quickly are more likely to outperform their rivals ([Stampfl et al., 2013](#)). The widespread impact of digital and AI transitions makes it increasingly important for established companies to develop internal scalability conditions ([Menz et al., 2021](#)) to avoid being left behind ([Vendrell-Herrero et al., 2025](#)). Incumbents can achieve exponential growth, but key requirements for doing so include rethinking market positioning as if they were new entrants, engaging with new value systems, implementing adaptation mechanisms, and aligning strategies with emerging opportunities.

The path toward scalability is only partially supported: adaptation is consistently associated with growth, while renewal contributes variably depending on firm size and technological intensity. Incumbents must engage with new value systems and implement adaptation mechanisms, but deliberate renewal is less critical in smaller or low-tech firms.

Scalability is much more than expanding in size or output; it also involves transforming business models to integrate operational efficiencies with market engagement ([Reuber et al., 2021](#)). Managers and decision-makers at incumbent firms must realign their existing competencies and structures to respond to technological and market shifts, reconfigure resources, and overcome inertia. This capacity to restructure quickly and establish adaptive organisations is associated with superior abilities to exploit scaling opportunities ([Gligor et al., 2016](#)) and harness scalable resources ([Giustiziero et al., 2023](#)). Strategic renewal may play a less central role in smaller or low-tech firms and should therefore be seen as context-dependent rather than universally essential.

In sum, ongoing capability development is important not only for

navigating dynamic markets but also for exploiting future opportunities ([Vaillant et al., 2025a](#)). Value recognition, adaptation, and renewal are the key stages linked by discovery, development, and exploitation that contribute to scalability. However, the importance of renewal varies by context. Together these mechanisms enable incumbent firms to overcome limitations and scale efficiently and effectively.

## 7.3. Limitations and future research opportunities

As with any theoretical model, replication studies are needed for further validation and contextualisation. For reasons of rigour and consistency, our constructs draw on measures established in the literature. As the expected results were obtained, future research could refine and disaggregate these constructs to test specific items and micro-processes within each stage, and especially the relationship between scalability capabilities and realised scale-up growth.

The mechanisms through which scalability is developed also warrant further investigation, particularly the “how” question. Qualitative, process-oriented research could complement our findings by exploring the generative mechanisms and contextual contingencies. Future studies could also extend the analysis beyond scalability to explore subsequent outcomes—such as performance, long-term viability, and the ability to respond to ongoing changes within broader value systems.

The cross-sectional nature of our data does not a priori allow for longitudinal heterogeneity analyses. We address this limitation by employing DoWhy to identify and validate hypothesised pathways ([Molak, 2023](#)). These algorithms detect potential causal associations in contexts involving latent constructs, drawing on econometric use of instruments to address reciprocal causation and endogeneity in cross-sectional data (e.g., [Aleksin & Sascha, 2024](#); [Sajons, 2020](#)). Thus, the cross-sectional design does not preclude causal path analysis. Our DoWhy analysis provides evidence consistent with the proposed scalability path across its stages. Although the absence of time lags remains a limitation, this is mitigated by strong mediation results supporting the progression towards scale-up capabilities in incumbent firms.

Nevertheless, longitudinal research is essential to better capture the temporal evolution of incumbent firms.

Finally, our sample focuses on medium to large Spanish manufacturing and service firms. While our findings may be relevant elsewhere, they may not fully generalise to very large multinationals or contexts where firm complexity, regulatory environments, and innovation practices may differ. Future research should examine different sectors, firm sizes, geographies, and distinctions between B2C and B2B organisations.

## 8. Conclusion

This study contributes to cumulative theory by refining and extending, rather than merely testing, the four-stage framework for scalability in incumbent firms originally developed through the Nvidia case (Vendrell-Herrero et al., 2025). By introducing technology as a moderating factor, analysing a more standard firm-size context, and examining partial mediation mechanisms, the analysis clarifies how and under what conditions incumbents progress across stages to achieve scalability. Evidence from a larger and more heterogeneous sample—operating under less exceptional conditions than Nvidia—suggests that value recognition, organisational adaptation, and strategic renewal (in that order) are antecedents of scalability. However, their explanatory relevance increases with technology intensity and firm size, and the pathway from adaptation to scalability via renewal is weaker than predicted in the original model. These findings refine the framework by highlighting important boundary conditions and qualifying the strength of specific pathways in broader empirical contexts.

## Declaration of generative AI and AI-assisted technologies in the writing process

During the preparation of this work the authors used DeepL and ChatGPT to revise the manuscript and improve language and readability. After using these tools, the authors reviewed and edited the content as needed and take full responsibility for the content of the publication.

## CRediT authorship contribution statement

**Oscar F. Bustinza:** Writing – review & editing, Writing – original draft, Visualization, Validation, Supervision, Software, Methodology, Investigation, Formal analysis, Data curation, Conceptualization. **Ferran Vendrell-Herrero:** Writing – review & editing, Writing – original draft, Visualization, Supervision, Methodology, Investigation, Formal analysis, Data curation, Conceptualization. **Yancy Vaillant:** Writing – review & editing, Writing – original draft, Supervision, Resources, Investigation, Data curation, Conceptualization.

## Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

## Acknowledgements

The authors are grateful to Michel Van der Borgh, Mirella Kleijnen, and the two anonymous reviewers for their insightful comments and constructive suggestions throughout the review process. Oscar F. Bustinza acknowledges support from Grant C-SEJ-020-UGR23 funded by Consejería de Universidad, Investigación e Innovación and by ERDF/EU Andalusia Program 2021–2027. Ferran Vendrell-Herrero acknowledges support by the Spanish State Research Agency (SRA), Ministry of Science and Innovation (Reference: PID2022-136235NB-I00). Yancy Vaillant acknowledges financial support from the Spanish Ministry of Science,

Innovation and Universities, Grant PID2024-162014NB-I00 funded by MICIU/AEI/10.13039/501100011033 and by ERDF/EU. Funding for open access charge was provided by Universidad de Granada/CBUA.

## Data availability

The data that has been used is confidential.

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