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The nonlinear relationship between digital affordances and firm-level export performance: The moderating role of organizational ambidexterity

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Abstract

A diminished trade cost has been ascribed to the advancement of digital transformation, particularly digital technologies and platforms. Nevertheless, whether this decline in trade costs manifests in the extensive or intensive margin of trade remains an unresolved query. This study conducts a comprehensive analysis of the influence of digital affordances on firm-level export performance. Specifically, we posit that digital affordances will manifest a convex influence on firms' export decisions and intensive margin of export. Furthermore, we propose that the relationship between digital affordances and firm-level export decisions will be contingent upon the degree of firms' organizational ambidexterity. To empirically test our hypotheses, we leverage a dataset comprising 13,251 firm-level observations gathered by the World Bank Enterprise Surveys (WBES) unit across 19 Organization for Economic Cooperation and Development (OECD) countries. Our study substantiates a U-shaped nexus between digital affordances and firm-level export performance. Importantly, our analysis supports that this U-shaped nexus is accentuated when firms present a high level of organizational ambidexterity.

1 | INTRODUCTION

Digital technologies, including digital devices, digital platforms, and artificial intelligence, have rapidly developed over the past several years. This evolution has led to significant transformation and refinement in organizational structures and strategies (Belitski et al., 2023; Li et al., 2023; Zhiyong et al., 2023). These advancements enable firms to enhance efficiency and create value by optimizing the production and management processes. Additionally, the advancement of digital technologies facilitates the utilization of innovative technologies and enables organizations to respond to flexible market requirements (Dias et al., 2022; Favoretto et al., 2022; Gao et al., 2022).

It is of paramount importance to obtain a more comprehensive understanding of the routines and mechanisms underlying the influence of digitalization on firms' behavior (Feliciano-Cestero et al., 2023). This understanding holds significant implications, as it can facilitate governments in obtaining their political and economic objectives more efficiently and effectively by establishing a strong connection between digital transformation and firms' behavior performance. In alignment with this objective, the Organization for Economic Cooperation and Development (OECD) has initiated the "Going Digital" project. This initiative aims to empower policymakers with a comprehensive understanding of digital transformation and equip them with the necessary insights to formulate well-suited policies that

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pave the way for a positive digital future. The substantial enhancements in innovation and production efficiency ushered in by digital technologies hold the potential to furnish firms with enhanced opportunities in foreign markets (Cardona et al., 2013; Jun et al., 2021).

Previous studies have consistently highlighted the favorable influence of digital transformation on firms' international strategies and achievements. Information and communication technology (ICT) has served as a key driver in facilitating export decisions and export intensity through various channels. These channels include online presence and online transactions (Hagsten & Kotnik, 2017), internet accessibility (Rodríguez-Crespo & Martínez-Zarzoso, 2019), and the adoption of cloud technologies (Boccia et al., 2022). Furthermore, digital services have emerged as a catalyst for green goods export (Ha & Thanh, 2022) and digital trade (Janow & Mavroidis, 2019). Additionally, digital platforms positively influence firms' performance in foreign countries, both through exploitation-driven forces (Caputo et al., 2022) and exploration-driven forces (Cassia & Magno, 2022).

However, it is essential to acknowledge that while most research has emphasized the positive influences of digital transformation on firms' trade activities and performance, there are noteworthy studies that have highlighted potential negative impacts during the digitalization process. For instance, some small and medium-sized enterprises (SMEs) may face challenges due to a shortage of expertise and resources necessary to address the issues arising from digital transformation (Narayanan, 2015). E-business technologies can adversely affect firms' internationalization performance when these technologies are not seamlessly integrated into organizational innovations and investments (Cassetta et al., 2020).

In summary, the ultimate influence of digitalization on firms' export performance is multifaceted and often contentious, considering both the positive influence brought about by digital transformation and the potential challenges encountered during digitalization. Some research suggests that the nexus between digitalization and export performance is nonlinear (Nham et al., 2023), but the latent mechanism remains a subject of inquiry. Consequently, this central research question addressed in this study pertains to how digital transformation influences firm-level export performance.

To address the research issue, our study introduces the concept of "digital affordances," which encompasses the digital artifacts embedded in new product or services, the utilization of digital platforms, and the advancement of digital infrastructure (Belitski et al., 2023). Our approach involves constructing a complex evaluation system to gauge the maturity of digital affordances and to evaluate their progression in 19 OECD countries over the period spanning 2010 to 2020. This evaluation serves as a foundation for exploring the nexus between digital affordances and firm-level export performance. Subsequently, we construct a probit model, incorporating a quadratic term of the primary explanatory variable, to investigate potential nonlinear relationships. Recognizing the issue of endogeneity, we introduce the instrumental variable method to mitigate this concern. Furthermore, we conduct a comprehensive series of robustness tests to ensure the validity of our results. Additionally, our paper delves into the moderating effects of organizational ambidexterity on the association between digital affordances and firms' export decisions. The moderating mechanism is discussed from two aspects: the alteration of the turning point and the reshaping of slopes within this relationship. Finally, our study extends its analysis to examine the impact of digital affordances on the intensive margin of export, shedding light on the intricacies of digital transformation's influence on the depth of firms' engagement in international trade.

This study offers several potential contributions to this field. First, it involves the meticulous measurement of the digital affordance levels across 19 OECD countries, spanning the period from 2010 to 2020. This comprehensive assessment provides a robust statistical foundation for the research of digital phenomena. Second, we theorize and empirically validate a U-shaped relationship between digital affordances and firm-level export activities. Diverging from the previous studies, most of which focus on linear effects, our study delves into the nuanced nonlinear effects of digital affordances on firms' export performance. This endeavor not only contributes new theoretical insights but also provides empirical evidence that advances our comprehension of the intricate relationship between digital transformation and export activities. Third, we investigate the moderating effect of organizational ambidexterity between digital affordances and export decisions. Organizational ambidexterity, defined as a firm's capability to effectively combine exploratory innovation and exploitative innovation (Tarba et al., 2020), is a critical aspect of this study. Our findings suggest that enhancing the level of organizational ambidexterity may lower the threshold at which firms make export decisions in response to digital affordances. Furthermore, organizational ambidexterity accentuates the U-shaped nexus between the impact of digital affordances and firms' export decisions.

The remaining sections of the study are structured as follows. Section 2 offers a relevant literature review. Section 3 outlines the research design, encompassing the establishment of the benchmark model, the model used to examine the moderating mechanism, and a detailed description of variables and data. Section 4 offers an in-depth analysis of the empirical results. Finally, Section 5 concludes the study by highlighting the contributions and acknowledging their limitations.

2 | LITERATURE REVIEW AND HYPOTHESES DEVELOPMENT

2.1 | Digital affordances and exports

Building upon the heterogenous trade model and drawing from prior theoretical frameworks, we seek to establish a meaningful connection between digital affordances and firm-level export activities. Digital affordances, in this context, emanate from the technical architecture of digital infrastructures and fundamentally reshape the processes of value creation and transportation within an economy (Autio et al., 2018). A comprehensive evaluation of digital affordances involves assessing them across three dimensions: the adoption of

digital artifacts in producing new products, the upgrading of digital platforms, and the advancement of digital infrastructure (Nambisan et al., 2017).

While previous studies suggest that digital technology and infrastructure can enhance the efficiency and convenience of communication, manufacturing, and transportation processes (Bouwman et al., 2019; Gao et al., 2022), consequently impacting export performance through a multifaceted approach to innovation (Edeh & Acedo, 2021), there still exists some ambiguity in understanding the underlying mechanism of digital transformation and export performance. This study takes a closer look at the direct and indirect effects of digital affordances on firms' export activities and explains the nonlinear relationships between digital affordances and firms' export activities. The "direct effects" pertain to channels that promote exports by reducing trade costs, while the "indirect effects" encompass channels that transform production processes (Zhou et al., 2022).

Trade costs play a pivotal role in influencing both the extensive and intensive margins of trade (Melitz, 2003). These costs encompass expenses incurred at each stage of trade activities and are typically comprised of fixed costs (often referred to as iceberg costs) and variable costs (often referred to as marginal costs) (Nham et al., 2023). Fixed costs entail expenditures related to market search, product promotion, and communication with prospective customers, as Freund and Weinhold (2004) emphasized. Melitz (2003) highlights that reducing fixed costs can lower the minimum productivity threshold necessary for firms to venture into foreign markets. Integrating information and communications technologies into business processes has notably diminished searching costs and improved customers and suppliers matchmaking (Mu et al., 2020; Wang & Li, 2017). Digital technologies have enhanced communication efficiency between customers and suppliers (Rehnberg & Ponte, 2018). Export-oriented firms can effectively and expansively promote their products in international markets, leveraging technological advancements (Nham et al., 2023). Digital technology not only affects fixed costs but also exerts an influence on variable costs. Variable costs refer to expenses that fluctuate with export values in international trade, such as transportation costs. Multinational enterprises can conveniently and expeditiously deliver products by leveraging digital platforms (Nham et al., 2023). In addition, the efficiency of the logistics industry has seen marked improvements due to enhanced digital infrastructure (Zhou et al., 2022), making products more accessible to foreign customers.

Digital affordances indirectly stimulate firms' export activities by facilitating resource distribution and innovation technologies within firms' production processes (Ren et al., 2021). The efficiency of firms' manufacturing processes and business operations is enhanced by assimilating new technologies (Comin & Mestieri, 2018). Export-oriented firms can experience accelerated growth by harnessing technological innovations (Azar & Ciabuschi, 2017). Furthermore, digital infrastructure and technology play a pivotal role in optimizing industrial structure, enhancing industrial competitiveness, and benefiting exporting enterprises within the industry (Zhou et al., 2022).

2.2 | Nonlinear relationship

While the beneficial effect of digital affordances on export activities is evident, it is essential to recognize the existence of unobservable forces that can impede these positive effects. Some researchers have proposed the existence of a U-shaped nexus between informational capabilities and export venture performance (Kaleka, 2012). Nham et al. (2023) also identified a U-shaped correlation between digitalization and export performance. Similarly, the J-shaped relationship suggests that nonlinear relationships in export performance are both plausible and worthy of further exploration (Ogasavara et al., 2016). It is imperative to analyze the latent mechanisms underpinning this phenomenon to gain a deeper understanding. According to Haans et al. (2016), two latent functions jointly shape the U-shaped relationship, with adverse forces playing a negative role between independent and dependent variables when combined.

In our study, we propose the introduction of multiplicative combinations to elucidate the underlying mechanism that give rise to the U-shaped relationship between digital affordances and firm-level export activities. The multiplicative combinations entail the interaction of a positive and a negative linear function in the explanatory variable (Haans et al., 2016). The "positive function" encompasses mechanisms conducive to promoting a firm's export, as discussed in Section 2.1, while the "negative function" represents the mechanisms that exert adverse influence during the process of enhancing digital affordances. As depicted in Figure 1, the positive function of digital affordances is on the rise, while the marginal effect of negative influences tends to diminish, owing to the shared effects of infrastructural advancement and technological improvement. This interplay results in the formation of a U-shaped curve. In this section, we analyze the latten mechanism by following three routines.

First, the U-shape nexus between digital affordances and a firm's export activities can be understood as a manifestation of the "too little of a good thing" effect (Nham et al., 2023). In particular, firms encounter a downturn in export performance when the level of digital affordance is below a certain threshold. Beyond the threshold, the downward-sloping line turns upward. Firms and manufacturing sectors can only unlock value creation when digital transformation technologies reach a critical mass (Asongu et al., 2020; Di Vaio et al., 2021). In essence, a threshold exists for digitalization to contribute to innovative production (Gong et al., 2023), resulting in a deferred positive impact on export performance.

Second, a misalignment frequently occurs between firms' internal and external factors and digital affordances development in the initial stages (Feliciano-Cestero et al., 2023), impeding digital capacity's influence on firms' export performance. Notably, the impact of ICT

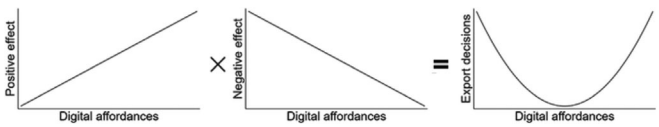

FIGURE 1 The latent mechanisms resulting in a U-shaped curve.

investment exhibits a progressively increasing effect on the upgrade of the industrial structure under a more favorable marketization environment (Yan et al., 2023). Simultaneously, firms are compelled to recalibrate their business models to enhance revenue streams through the adept deployment of digital offerings (Gebauer et al., 2020).

Third, attaining an optimal threshold for management practices and enabling the full realization of digital affordances necessitate substantial investments, often amounting to hundreds of millions of dollars (Bughin et al., 2019). Adapting business models to accommodate digitalization encompasses hardware upgrading, radical innovations, and the integration of novel business models and digital capacity (Gebauer et al., 2020). This transformative process entails significant financial costs and temporal investments. Additionally, energy consumption rises rapidly due to the limited availability of digital technology and high demands on supporting infrastructure (Lin & Huang, 2023). Consequently, the positive effect of digital affordances may not always offset the negative effect resulting from the expensive initial investment.

In summary, it becomes evident that low levels of digital affordances exhibit limited positive effects on firms' export performance. Furthermore, the negative effects stemming from hindering factors tend to wane as digital technology advances and digital infrastructure improves. Building upon the theoretical analysis presented above, we posit the hypothesis as follows:

> **H1.** Digital affordances exhibit a U-shaped effect on firm-level export performance.

2.3 | Moderating effects of organizational ambidexterity

In the backdrop of an increasingly intricate and swiftly evolving business environment, it becomes imperative for firms to craft the capabilities that facilitate an equilibrium between exploiting existing resources and exploring future abilities for management decision-making (Yunita et al., 2023). As articulated by Raisch et al. (2009), ambidexterity epitomizes an organization's adeptness in simultaneously optimizing its present managerial practices to maximize revenue while harnessing new opportunities and cutting-edge technological innovations (Clauss et al., 2021). The exploitation facet empowers firms to elevate productivity and streamline costs by improving pre-upgrading existing services and products (O'Cass et al., 2014). In contrast, the exploration dimension propels firms to proactively obtain and seamlessly integrate novel insights and technologies, thereby forging innovative sources of competitive advantages (Jurksiene & Pundziene, 2016; O'Cass et al., 2014).

Within the sphere of contemporary management practices, the demands of exploitation activities and exploration activities manifest as two opposed forces vying for the unwavering attention of executives and the judicious allocation of managerial resources, all in pursuit of the elusive goal of optimal performance (O'Reilly & Tushman, 2013). This inherent tension, exacerbated by variations in supportive strategies and organizational structures, precipitates a trade-off between exploitative and explorative innovation endeavors (Smith & Tushman, 2005). Hence, firms must balance exploitation and exploration to make rational and efficient utilization of resources and cultivate innovative abilities for advanced outputs (Junni et al., 2013). Studies have concluded that the amalgamation of exploitative and explorative capabilities contributes to firms' ability to effectively and efficiently react to the volatile environment (Aljumah et al., 2021; Rialti et al., 2019).

In the course of international business, the focus of firms' management strategies tends to shift away from the enhancing existing resources and processes when exploitation capability is low (Uotila et al., 2009). Such firms may find it challenging to achieve scale economies and establish pathways to enter external markets (Yan et al., 2021). Conversely, firms endowed with a high level of exploitation capability tend to see improvements across various dimensions, such as production processes, promotional strategies, and transportation. These enhancements stem from managers' heightened understanding and refinement of their current organizational performance in exporting markets (Cieślik et al., 2015; Jean et al., 2010). However, there is a caveat: firms overly reliant on exploitation capability, particularly in well-established markets, may exhibit reduced enthusiasm to explore new markets (Walrave et al., 2011). In other words, firms emphasizing exploitation capability may be trapped in the short-term "success illusion" since they lack the ability to cope with the rapidly changing environment (Uotila et al., 2009). Firms must embrace exploration-oriented innovation to avoid succumbing to the "success trap" and effectively respond to the glowing dynamics of international markets. This approach involves the development of cutting-edge technologies and introducing new information, enabling long-term success (Ferreras-Méndez et al., 2022; Uotila et al., 2009).

Firms adopting an exploration strategy not only initiate entry into export markets with fresh ideas but also advance their innovation capabilities through exposure to the international environment (Love & Ganotakis, 2013). Managers tend to focus inwardly on internal affairs when the level of exploration ability is low, which can result in reduced sales and revenues due to the limited knowledge spillovers from exporting markets (Yan et al., 2021). In contrast, firms with higher levels of exploration capability are more proposed to interact with and harness external resources (Minbaeva et al., 2014). In essence, firms equipped with superior exploration perform more effectively in the exporting market, owing to their enhanced understanding of the complexities of the international business landscape (Yan et al., 2021). Nonetheless, the outcomes of exploration activities are uncertain in the long run (Uotila et al., 2009), potentially ensnaring firms in a "failure trap," where "failure leads to search and change which leads to failure which leads to more search, and so on" (Levinthal & March, 1993). Moreover, firms with high level of exploration capability may misestimate the challenges and costs associated with failure (Assink, 2006), impeding firms' course to venture into new markets (Ferreras-Méndez et al., 2022). In such contexts, the exploitative routines inherent in organizational ambidexterity can mitigate the potential negative impacts of an exploration-oriented strategy.

These routines can facilitate optimal market entry speed and decision-making (Ferreras-Méndez et al., 2022; Huang et al., 2020).

In a comprehensive view, firms stand to gain advantages by not only identifying new routines within the international market but also by optimizing existing resources (Yan et al., 2021). Building upon these insights, the arguments presented thus far imply that organizational ambidexterity assumes a pivotal role in reinforcing the U-shaped nexus between firm-level export decisions and the impact of digital affordances. On the one hand, organizational ambidexterity enhances firms' sensitivity to digital affordances, promoting more proactive adjustments in their export decisions. On the other hand, firms which are adept at balancing exploitation and exploration are more agile in harnessing the potential benefits and mitigating the challenges posed by digital affordances, thus fine-tuning their export behavior with greater precision. Consequently, we posit the following hypotheses:

H2. The turning point of the U-shaped curve will shift leftwards for firms characterized by a higher degree of organizational ambidexterity.

H3. Organizational ambidexterity accentuates the U-shaped relationship between digital affordances and firm-level export decisions. Specifically, the slopes of the U-shape curve become more steepening for firms exhibiting a higher level of organizational ambidexterity in comparison to their counterparts with a lower level of ambidexterity.

3 | RESEARCH DESIGN

3.1 | Benchmark regression model

According to prior studies, the nexus between digital affordance and firms' export decisions exhibits a nonlinear nature and can be aptly described as following a U-shaped curve. The benchmark regression model to investigate these nonlinear effects is articulated as follows:

$$EX_{ijkt} = \alpha_0 + \alpha_1 DA_{it} + \alpha_2 DA_{it}^2 + \beta X_{ijkt} + \delta_i + \theta_j + \gamma_t + \varepsilon_{ijkt} \quad (1)$$

where the subscripts *i*, *j*, *k*, and *t* correspond to country, industry, firm, and year, respectively. Specifically, EX_{ijkt} denotes the export decision for firm *k* in country *i*, operating within a two-digit industry *j*, during year *t*. This variable is binary in nature, taking value one if the firm engages in exporting and zero otherwise. DA_{it} and DA_{it}^2 represent the digital affordance of country *i* in year *t*, along with its squared term, respectively. X_{ijkt} encompasses a set of firm-level control variables. Additionally, δ_i, θ_j, and γ_t represent country-fixed effects, industry-fixed effects, and survey-year-fixed effects, respectively. Country and industry fixed effects are incorporated to control for the unobserved heterogeneity specific to the country and industry level. Year-fixed effects are introduced to capture the various shocks over time that may affect firms' behaviour. Furthermore, ε_{ijkt} serves as an error term, adhering to the assumption of being identically and independently distributed with a mean of zero and constant variance.

To estimate Equation (1), wherein the dependent variable EX_{ijkt} is binary in nature, we employ a probit regression model. Our primary focus in this study is centred on the coefficients associated with the core explanatory variable and its quadratic term, namely DA_{it} and DA_{it}^2. The identification of a U-shaped relationship between digital affordances and firms' export decisions hinges on the significance of α_2, which should exhibit a positive sign. The results are accompanied by standard errors clustered at the country level. With the aim of clarity and ease of interpretation, we also provide average marginal effects alongside the regression coefficients.

3.2 | Moderating effect model

In the dynamic interplay between digital affordances and their influence on firms' export decisions, it is imperative to acknowledge the potential presence of contextual factors that may exert a regulatory effect on these impacts. We employ a moderating effect model following Haans et al. (2016) to delve deeper into the intricate mechanisms at play. The specific model structure is articulated as follows:

$$EX_{ijkt} = \alpha_0 + \alpha_1 DA_{it} + \alpha_2 DA_{it}^2 + \alpha_3 DA_{it} \times ambi + \alpha_4 DA_{it}^2 \times ambi + \beta X_{ijkt} + \delta_i + \theta_j + \gamma_t + \varepsilon_{ijkt} \quad (2)$$

where *ambi* represents the moderating variable, specifically denoting the level of organizational ambidexterity within firms. To account for the moderating influence, we introduce the interactions terms $DA_{it} \times ambi$ and $DA_{it}^2 \times ambi$ which represent the products of moderator and digital affordances, as well as the moderator and the squared term of digital affordances, respectively. The interpretation of the remaining symbols aligns with their definitions in Equation (1).

In the context of the nonlinear model, it is essential to note that the assessment of the moderation effect does not solely hinge on the significance of the interaction term. This is owing to the inherent complexities in algebraically deriving interaction effects (Haans et al., 2016). A significant coefficient of an interaction term does not imply a significant moderating effect, and conversely, a significant moderating effect can exist for certain observations even in the absence of significant interaction term coefficients (Hoetker, 2007). Consequently, our analysis delves into the moderation effect through both mathematical and graphical means, providing a comprehensive understanding of the interplay among digital affordances, organizational ambidexterity, and firms' export decisions.

Specifically, the moderating variable *ambi* can influence the U-shape relationships in two distinct ways, as elucidated by Haans et al. (2016): it can shift the turning point of the U-shaped curve either to right or left when compared to the results obtained from the benchmark regression, and it can flatten or steepen the U-shape relationships. The moderation effects on turning point and slopes need to

be assessed individually. In some instances, the moderating variable can affect the mechanisms in a manner that the location of turning point changes while the curve's slope may remain the same. Alternatively, the turning point and slope undergo simultaneous alterations (Haans et al., 2016).

To test the moderating effect within the nonlinear model, we can follow the route proposed by Haans et al. (2016).

Given the specification in Equation (2), we get the first-order condition by taking the derivate of the export decision variable (EX) with respect to digital affordances (DA):

$$\frac{\delta EX}{\delta DA} = \beta_1 + 2(\alpha_2 + \alpha_4 ambi) \times DA + \alpha_3 ambi = 0 \quad (3)$$

Subsequently, we can calculate the value of the turning point by solving for DA in Equation (3):

$$DA^* = \frac{-(\alpha_1 + \alpha_3 ambi)}{2(\alpha_2 + \alpha_4 ambi)} \quad (4)$$

Testing for the moderation effect on the turning point can be accomplished by calculating the derivative term of DA^* in Equation (4) with respect to the moderator variable *ambi*:

$$\frac{\delta DA^*}{\delta ambi} = \frac{\alpha_1\alpha_4 - \alpha_2\alpha_3}{2(\alpha_2 + \alpha_4 ambi)^2} \quad (5)$$

The direction in which the turning point shifts is contingent upon the sign of the expression $\alpha_1\alpha_4 - \alpha_2\alpha_3$ as indicated by the denominator being strictly greater than zero. Specifically, as the level of organisational ambidexterity $(ambi)$ increases, the turning point DA^* shifts to the left if $\alpha_1\alpha_4 - \alpha_2\alpha_3 < 0$ and to the right if $\alpha_1\alpha_4 - \alpha_2\alpha_3 > 0$.

Furthermore, to formally test the significance of Equation (5), we assign a specific value to *ambi* and evaluate the resulting equation.

In assessing the flattening or steepening moderation effect, we can calculate the corresponding slopes by assigning two or more meaningful values *ambi*. The slopes, denoted as S, are computed at a given distance (represented by a) to the right of the turning points in accordance with Equation (6). This calculation is repeated for various values of a, yielding a series of slopes. By comparing the changing magnitude of this series of slopes, we can ascertain whether the U-shaped curve is flattening or steepening in response to variations in organizational ambidexterity.

$$S = \alpha_1 + 2\alpha_2(a - DA^*) + \alpha_3 ambi + 2\alpha_4(a - DA^*) \times ambi \quad (6)$$

3.3 | Variable selection and data discussion

3.3.1 | Explained variables: export decisions

The focal explained variable within our study pertains to firms' export decisions, which is regarded as the extensive margin of trade. While recent research have predominantly explored the impact of digital technologies on the intensive margin of trade (Feng et al., 2023; Zhou et al., 2022), the substantial relevance of the extensive margin of trade persists in this study, given its pronounced influence on trade flows. According to forecasts derived from the Melitz model, approximately 50% of variation in exports can be attributed to the extensive margin of trade, emphasizing its crucial role in trade dynamics (Fernandes et al., 2023). Additionally, traditional trade flow estimates are biased due to the omission of the extensive margin (Helpman et al., 2008). The comprehensive comprehension and quantification of the determinants that affect the extensive margin of trade are significant for assessing the ramifications of diverse policies (Santos Silva et al., 2014). Furthermore, studies pertaining to the extensive margin of trade necessitate scrutiny at firm-level of aggregation (Hinz et al., 2019).

The variable EX_{ijkt} is a dummy variable that assumes a value of one when the firm engages in export activities and zero otherwise. In our study, approximately 44.16% of the sample firms conduct export activities, while the remaining 55.84% do not engage in export. This information offers an overview of the distribution of export decisions within the sample and is essential to understanding the characteristics of the firms under study.

3.3.2 | Core explanatory variable: digital affordance

Digital affordance, as conceptualized in this study, is a multifaceted perception that encompasses various dimensions. The construction of the digital affordances index present across 19 OECD countries during the period spanning 2010 to 2020. The index system is built upon a conceptual understanding and evaluation of digital affordances. Considering the availability of relevant data at the country level and drawing upon the measurement established by Belitski et al. (2023), the index system comprises nine indicators. These indicators are designed to capture the interplay among digital artifacts integrated in new products or services, digital platform, and digital infrastructure, which constitute the three key components of digital affordances (Belitski et al., 2023). These indicators included are as follows: total export of digital services, exports of digital services as a percent of total exports, total exports of ICT services, international bandwidth, fixed-broadband subscriptions per 100 inhabitants, percentage of the population using the Internet, mobile-broadband subscriptions per 100 inhabitants, mobile-cellular telephone subscriptions per 100 inhabitants, and fixed-telephone subscriptions per 100 inhabitants.

A principal-component factor analysis (PCA) is employed to assess the digital affordances index. PCA stands as a prevalent technique in prior studies for amalgamating variables into novel, linearly associated components (Allen et al., 2014), since its capacity to derive these components without additional preconception from the original data (Cámara & Tuesta, 2014). The general procedure of PCA commences by formulating the correlation matrix R. Subsequently, evaluation of R involves computing its eigenvalue, variance contribution

rates, and cumulative variance contribution rates. Following this, the extraction of principal components takes place, whereby a principal component loading matrix is established to derive the principal components. Concurrently, an eigenvector matrix is constructed to ascertain the weights for a comprehensive index. The last stage involves the computation of principal component scores. The specific steps for executing this analysis encompass the following.

Step 1. Standardization of the raw data of the nine indicators

The original data are standardized using *z*-score method to mitigate the influence of the variations in magnitude and units across the indicators utilized in estimating digital affordances index. The applications of the *z*-score effectively mitigate the relevance of measurement scale. Equation (7) is employed to derive the standardized index value, normalizing to

$$X_{ij} = \frac{x_{ij} - \mu_j}{\sigma_j} (i = 1,2,...,19; j = 1,2,...9) \quad (7)$$

where X_{ij} and x_{ij} represent the standardised value and original value of indicator j for country i, respectively. μ_j denotes the mean value indicator j of all countries. σ_j represents the standard deviation of indicator j for all countries.

Step 2. Evaluation of the applicability of PCA

The Cronbach's alpha reliability test statistic yielding a value of .86 indicates a robust degree of correlation among the primary indicators of digital affordances. This result validates the establishment of a scale variable underpinning the measurement of the digital affordances index. Moreover, the rejection of the null hypothesis in the Bartlett test of sphericity provides evidence of intercorrelation among the variables. This outcome further substantiates the suitability of utilizing PCA for creating the digital affordance index.

Step 3. Calculation of covariance matrix

Given the standardized data X_{ij} we proceed to calculate the covariance matrix $R = (r_\eta)_{m \times n}$. The covariance r_{ij} is determined by using Equation (8).

$$r_{ij} = \frac{1}{19-1} \sum_{i=1}^{19} y_{ii} y_{ij} \quad (8)$$

where $r_{ij} = r_{ji}$, $r_{ii} = 1$ and R is a symmetric matrix.

Step 4. Calculation of eigenvectors and eigenvalues

The eigenvalues $(\lambda_1 \geq \lambda_2 \geq ... \geq \lambda_9)$ are derived from the characteristic equation $|R - \lambda I| = 0$. Simultaneously, the associated eigenvectors can be computed from the system of homogeneous linear equations $|R - \lambda I|V = 0$, as illustrated in Equation (9).

$$V_j = (l_{1j}, l_{2j}, ..., l_{19j})^T, (j = 1,2,...9) \quad (9)$$

Step 5. Extraction of the principal factors

In this step, we arrange the eigenvalues in descending order and select the top k eigenvectors based on the largest eigenvalues to construct the eigenvector matrix. The outcome of the PCA reveals that three principal components satisfactorily capture the variance in the data, adhering to the Kaiser criterion, which stipulates retaining eigenvalues greater than 1. These three principal components collectively account for 77.34% of the variance in the primary data.

Step 6. Calculation of the comprehensive score of digital affordances

Upon acquiring the weights associated with each principal component, the comprehensive scores for the digital affordances are computed using Equation (10).

$$DA_{it} = \frac{\sum_{k=1}^{3} \lambda_k P_{kj}}{\sum_{k=1}^{3} \lambda_k} \quad (10)$$

where DA_{it} is the digital affordances of country i in year t. λ_k represents the weight of the three extracted principal components. P_{kj} is a linear combination of the three components and the eigenvectors of the respective correlation matrices. Clearly, a higher value of DA_{it} indicates a more advanced level of regional development in digital affordances. The estimated values of the digital affordances for 19 OECD countries spanning from 2010 to 2020 are detailed in Table 1.

3.3.3 | Control variables

Ln_scale represents the natural logarithm of the number of permanent full-time employees in a firm, which reflects the firm's scale. Firms with larger scale are often in a favorable position to lower costs, aligning with the principles of the new-trade theory. This cost advantage enables larger firms to more readily enter international markets, as they can afford the fixed costs associated with internationalization (Ha et al., 2021). *Ln_age* is introduced to control for the influence of a firm's age on its behavior. The number of years a firm has been in operation affects its ability to absorb learning, acquire technical skills, and develop technology. Older firms tend to have a greater ability to produce and export, making them more inclined to engage in international trade. *Ln_exp* represents the natural logarithm of the top manager's operating experience in the firm's specific industry. Managers with more extensive experience are often better equipped to make informed export decisions, as they possess a deeper understanding of the cultural nuances and political environments in international markets (Ha et al., 2021). *Ln_wage* is introduced to reflect firms' labor productivity from various perspectives. Higher labor productivity is linked with a higher likelihood of engaging in export activities, as firms with higher productivity can often produce goods or services more

TABLE 1 **TABLE 1.** Digital affordances index of 19 OECD countries from 2010 to 2020.

Country/year	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Belgium	1.77	1.74	1.70	1.85	1.83	1.78	1.73	1.73	1.68	1.62	1.56
Chile	0.27	0.32	0.38	0.45	0.50	0.67	0.67	0.63	0.70	0.65	0.66
Colombia	0.10	0.01	0.10	0.31	0.68	0.58	0.63	0.61	0.58	0.60	0.68
Costa Rica	0.18	0.28	0.40	0.53	0.59	0.68	0.65	0.67	0.66	0.69	0.79
Czech Republic	0.84	0.86	0.81	0.74	0.73	0.65	0.66	0.63	0.63	0.64	0.62
Estonia	0.53	0.54	0.66	0.67	0.72	0.72	0.72	0.70	0.72	0.72	0.74
Greece	0.32	0.31	0.32	0.32	0.29	0.25	0.24	0.27	0.28	0.29	0.24
Hungary	0.77	0.73	0.65	0.57	0.56	0.50	0.52	0.51	0.47	0.49	0.47
Israel	1.18	1.28	1.31	1.25	1.21	1.38	1.46	1.47	1.52	1.62	1.64
Italy	2.27	2.12	1.99	1.52	1.41	1.29	1.26	1.21	1.20	0.99	1.02
Latvia	0.49	0.44	0.49	0.51	0.41	0.45	0.47	0.53	0.51	0.51	0.53
Lithuania	0.32	0.36	0.33	0.34	0.34	0.33	0.37	0.38	0.46	0.53	0.46
Luxembourg	2.44	2.48	2.50	2.87	2.73	2.67	2.52	2.45	2.38	2.33	2.26
Mexico	0.05	0.11	0.11	0.33	0.26	0.36	0.33	0.33	0.27	0.24	0.23
Poland	1.04	1.01	0.96	0.80	0.91	0.75	1.00	1.05	1.11	1.12	1.11
Portugal	0.45	0.39	0.34	0.38	0.38	0.38	0.37	0.36	0.37	0.36	0.40
Slovenia	0.47	0.39	0.35	0.34	0.30	0.28	0.30	0.32	0.31	0.35	0.33
Sweden	2.63	2.71	2.72	2.12	2.05	2.05	1.90	1.78	1.69	1.67	1.68
Turkey	0.11	0.14	0.10	0.31	0.34	0.42	0.43	0.57	0.68	0.78	0.82

efficiently (Eck et al., 2015). Foreign ownership (*Foreign_own*) is used to control for foreign-owned firms, which is supposed to have a positive influence on firms' export decisions (Greenaway et al., 2007). External networking is captured by the proportion of material inputs or supplies originally imported from foreign countries (*Foreign_ori*). This variable is anticipated to influence firms' export decisions positively. Research and development (*RD*) and international certificate (*Certificate*) are dummy variables, which, respectively, represent a firm's innovation intention and innovation ability. Innovating firms are often seen as more reliable and capable, which can enhance their export prospects (Doan et al., 2020).

3.3.4 | Moderating variable: organizational ambidexterity

In exploring the mechanism that underlies the relationship between digital affordances and firms' export decisions, a pivotal consideration is the moderating effect exerted by organizational ambidexterity. The quantification of organizational ambidexterity is evaluated through a hybrid methodology integrating the Technique for Order Preference by Similarity to Ideal Solution (TOPSIS) and the entropy method. TOPSIS stands as a widely adopted integrated assessment method due to its transparent calculation process and its independence from specific data characteristics (Zavadskas et al., 2016). However, TOPSIS may result in biased estimation as it heavily depends on experts' subjective assessments to determine weight (Zeng et al., 2022). To address this potential issue and obtain a more objective assessment, TOPSIS is coupled with the entropy weight method. This combination allows for the incorporation of information deriving from the indicators with higher reliability and accuracy, thereby mitigating the influence of subjective measurements (Tang et al., 2023).

The evaluation of a firm's organizational ambidexterity encompasses a range of indicators, referring to the following indicators highlighted by Yunita et al. (2023): (1) score on the action when a problem arose; (2) score on the achievability of production/service provision targets; (3) score on knowledge of production/service provision target; (4) firm's capacity utilization; (5) whether the firm has internationally recognized quality certification; (6) whether the firm uses technology licensed from foreign companies; (7) whether the firm introduces a new product/service; (8) whether the firm introduces a process innovation; (9) whether the firm's new product/service is also new to the main market; and (10) whether the firm spend its revenue on research and development. The specific evaluation steps are as follows.

Step 1. Standardization of each indicator

The original data for each indicator undergoes standardization using the extremum method, as described by Equation (11).

$$X_{ij} = \frac{x_{ij} - \min(x_{ij})}{\max(x_{ij}) - \min(x_{ij})} \tag{11}$$

where X_{ij} and x_{ij} represent the standardised data and raw data for the specific indicator j of evaluation object i, respectively. $\max(x_{ij})$

and $\min(x_{ij})$ signify the maximum and minimum value of indicator j across all evaluation objects, respectively.

Step 2. Calculation of weight

The weight assigned to each indicator, w_j is obtained through the calculation of the information entropy e_i using equations (12) and (13).

$$e_i = -k\sum_{i=1}^{m} P_{ij} lnP_{ij} \tag{12}$$

$$w_j = \frac{1-e_j}{\sum_{j=1}^{n}(1-e_j)} \tag{13}$$

where $k = 1/lnn$ and $P_{ij} = X_{ij}/\sum_{i=1}^{m} X_{ij}$. P_{ij} is the dimensionless matrix. $1-e_j$ is the redundancy of the information entropy e_j.

Step 3. Construction of weighting matrix

$$M_{ij} = (m_{ij})_{m\times n} = w_j \times X_{ij} \tag{14}$$

Step 4. Calculation of positive and negative ideal solutions S^+ and S^-

$$\begin{cases} S_j^+ = \left\{ \max\limits_i (m_{ij}), i = 1,2,\ldots m \right\} \\ S_j^- = \left\{ \min\limits_i (m_{ij}), i = 1,2,\ldots m \right\} \end{cases} \tag{15}$$

Step 5. Calculation of Euclidean distance of ideal solutions

$$\begin{cases} D_i^+ = \sqrt{\sum_{j=1}^{n}\left(S_j^+ - m_{ij}\right)^2} \\ D_i^- = \sqrt{\sum_{j=1}^{n}\left(S_j^- - m_{ij}\right)^2} \end{cases} \tag{16}$$

Step 6. Calculation of relative proximity to ideal solution of each object

$$ambi_i = \frac{D_i^-}{D_i^+ + D_i^-}, 0 \le ambi_i \le 1 \tag{17}$$

The ideal solution is the organizational ambidexterity for each firm.

3.3.5 | Statistics description

The data used in this study are sourced from multiple reputable organizations. The independent variable relies on country-level statistics collected by OECD data. The dependent variables and other relevant variables are derived from pooled cross-sectional data at the firm level, which are maintained by the World Bank Enterprise Surveys (WBES) unit. Additionally, the indicators utilized to construct the moderating variable are also selected from the survey conducted by the WBES unit. The sample firms included in the WBES dataset are drawn from multiple countries across different regions globally. The high credibility and authority of the WBES data can be attributed to its rigorous data collection instruments and procedures. The WBES unit uses a stratified random sampling technique to gather data on a wide spectrum of business environment topics, encompassing areas such as regulations, taxation, corruption, finance, management practices, and trade. For the detailed survey methodology, information can be accessed in the "Enterprise Surveys" documentation (https://www.enterprisesurveys.org/en/methodology). It is vital to note that not all the OECD countries are incorporated in the study because some of them have not undergone the survey conducted by the WBES unit.

The final dataset comprises 13,251 observations encompassing 19 OECD countries for the years 2010, 2013, 2014, 2017, 2018, 2019, and 2020. The data of manufacturing firms are kept, as the prime concentration of the study is on the manufacturing sector and the trade theory is applicable in this sector. Further details regarding the survey conducted year and the corresponding OECD countries used in this study are shown in Table 2. Additionally, Table 3 reports a description of all variables employed in this analysis. Table 4 offers insights into the average characteristics of the sample firms under examination.

3.4 | Estimation methods

We employ several tests and measures to enhance our findings' robustness. First, a *U*-test is utilized to examine the validity of the U-shaped relationships. Second, we enhance the robustness of the regression by introducing the proportion of state ownership in the firm (*State*) as a control variable. Furthermore, we employ the robit model as an alternative statistical approach to mitigate the potential influence of outliers. Moreover, we address the potential issue of measurement error of the digital affordances index by introducing an alternative measurement approach. In this regard, we re-evaluate digital affordances using the entropy evaluation method.

However, there may still be some concerns related to the endogeneity that could introduce biased estimates. The first concern arises from the possibility that digital affordances and firm-level decisions are correlated with unobservable firm characteristics. Firm-fixed effects is not a feasible option to tackle this issue when dealing with pooled cross-section data (Kul Kapri, 2019). The second concern pertains to reverse causality bias. This bias may arise because more productive firms, such as exporters, have the capacity to accumulate greater wealth and resources for local development. Consequently, countries hosting these productive firms may be more inclined and capable to improve their digital affordances.

TABLE 2 **TABLE 2.** Number of firms by year.

Year	Country	Number of firms
2010	Chile	780
	Colombia	708
	Costa Rica	322
	Mexico	1175
2013	Czech Republic	114
	Estonia	86
	Hungary	98
	Israel	201
	Latvia	118
	Lithuania	107
	Poland	191
	Slovenia	85
	Turkey	1085
2014	Sweden	337
2017	Colombia	570
2018	Greece	315
2019	Czech Republic	291
	Estonia	135
	Hungary	481
	Italy	461
	Latvia	130
	Lithuania	128
	Poland	1004
	Portugal	775
	Slovenia	176
	Turkey	1065
2020	Belgium	243
	Luxembourg	37
	Sweden	350

TABLE 3 **TABLE 3.** Description of variables.

Variables	Descriptions
EX	0/1 dummy for a firm that is an exporter
DA	The digital affordance index of 19 OECD countries
Ln_scale	The natural logarithm of the number of permanent full-time employees
Ln_age	The natural logarithm of a firm's number of existing years
Ln_exp	The natural logarithm of years of the top manager's experience working in the firm's sector.
Ln_wage	The natural logarithm of the ratio of total labor cost to the number of permanent full-time workers
Foreign_own	The proportion of private foreign ownership in a firm
Foreign_ori	0/1 dummy for firms using material inputs and/or supplies of foreign origin
RD	0/1 dummy for firms that spent on formal research and development activities during the last fiscal year
Certificate	0/1 dummy for firms owning an internationally recognized quality certification
ambi	Moderating variable used to proxy for the level of firms' organizational ambidexterity

TABLE 4 Descriptive statistics.

Variables	Obs.	Mean	Std. Dev.	Min	Max
EX	11,442	0.442	0.497	0	1
DA	11,565	0.601	0.488	0.035	2.245
Ln_scale	11,437	3.553	1.341	0	8.431
Ln_age	11,402	2.991	0.784	0	5.394
Ln_exp	11,281	2.988	0.7	0	4.094
Ln_wage	8872	12.075	2.754	−1.609	21.886
Foreign_own	11,416	9.016	27.357	0	100
Foreign_ori	11,081	0.624	0.484	0	1
RD	7312	0.337	0.473	0	1
Certificate	11,231	0.432	0.495	0	1
ambi	11,564	0.355	0.225	0	1

We utilize the instrumental variables (IV) method to mitigate these potential endogeneity issues. In this approach, our chosen instrument for digital affordances is a carefully constructed variable: the interaction term of home computer access in the year 2009 and the growth rate of the population using the Internet in the survey's conducted year and country. This instrument variable is inspired by the Bartik instrument approach, originally formed by the interaction between local industry shares and national industry growth rates to evaluate the causal effect of a policy on employment outcomes. Variants of the Bartik instrument have been widely used across many fields, including international trade and macroeconomy (Goldsmith-Pinkham et al., 2020).

In the part of mechanism analysis, we employ statistical techniques to assess the moderating effect of the turning point and the shape. Sequentially, the graphical representation provides insight into the interaction effects' magnitude and relevance.

Additionally, our analysis extends to exploring the connection between digital affordances and the intensive margin of international trade. To apprehend the intensive margin of export, we calculate the proportion of firm's exported value to total sales, encompassing both direct and indirect exports.

4 | RESULTS

4.1 | Main results

The variance inflation factor (VIF) and tolerance are calculated to assess the presence of multicollinearity issues between the core independent variable and all other variables. The results, presented in Table 5, demonstrate that there is no multicollinearity among the

TABLE 5 Variance, inflation factor (VIF) and tolerance.

Variables	VIF	Tolerance
DA	1.17	0.8557
Ln_scale	1.28	0.7816
Ln_age	1.18	0.8469
Ln_exp	1.07	0.9371
Ln_wage	1.10	0.9104
Foreign_own	1.16	0.8614
Foreign_ori	1.16	0.8618
RD	1.69	0.5902
Certificate	1.31	0.7615
ambi	1.98	0.5046
Mean VIF	1.31	

exogenous variables. Specifically, all VIF values fall comfortably below the threshold of 5, while the tolerance values exceed the minimum criterion of 0.1.

H1 posited a U-shaped nexus between digital affordances and firm-level export decisions. The outcomes of the regression analysis, as presented in Table 6, provide insights into the nonlinear effect of digital affordances on firms' export decisions. The results in column (1) control for firm characteristics, country effects, two-digit industry effects, and time effects. As demonstrated in column (1), the coefficient of digital affordances on firm-level export decisions is statistically negative, while the coefficient of quadratic term of digital affordances is statistically positive. These results indicate the presence of a convex nexus between digital affordances and firm-level export decisions. Initially, firms' inclination towards export diminishes. Once the turning point is surpassed, export decisions exhibit an upward trajectory in response to improvement in digital affordances. This suggests that firms are more inclined to export when digital affordances have developed to a certain optimal level. Furthermore, adopting the strategy articulated by Lind and Mehlum (2010), we validate the average marginal effect. As presented in column (2) of Table 6, the probability of firms entering the exporting market increases by 1.273% with a 1% increase in digital affordances once digital affordances have reached an optimal degree. These findings provide support for H1.

This curvilinear nexus between digital affordances and export decisions aligns with the prior studies that have explored the connection between digital transformation and export activities (Nham et al., 2023). In the short term, digital affordances may necessitate firms to grapple with the misalignment between information resources and productivity (Feliciano-Cestero et al., 2023), thereby exerting a negative influence on firms' export intentions. However, as digital affordances continue to evolve, firms cease to adapt passively and, instead, proactively embrace dynamic external environment through innovative development and technological advancement (Asongu et al., 2020; Gong et al., 2023), thereby enhancing their competitive advantages and augmenting the likelihood of export activities. This transformation is consistent with the previous theoretical analysis.

TABLE 6 Benchmark estimation results.

	(1)	(2)
Variables	EX	Marginal effect
DA	−6.421***	−1.784***
	(0.610)	(0.168)
DA^2	4.583***	1.273***
	(0.684)	(0.190)
Ln_scale	0.235***	0.065***
	(0.033)	(0.008)
Ln_age	0.014	0.004
	(0.041)	(0.011)
Ln_exp	−0.014	−0.004
	(0.030)	(0.008)
Ln_wage	0.071**	0.020**
	(0.034)	(0.010)
Foreign_own	0.623***	0.173***
	(0.085)	(0.023)
Foreign_ori	0.514***	0.143***
	(0.113)	(0.029)
RD	0.286***	0.079***
	(0.076)	(0.021)
Certificate	0.487***	0.135***
	(0.058)	(0.016)
Constant	−3.278***	
	(1.160)	
Observations	5219	5219
Country FE	YES	YES
Industry FE	YES	YES
Year FE	YES	YES

Robust standard errors in parentheses.
***$p < .01$.**$p < .05$.*$p < .1$.

As regards the impacts of other control variables in the estimation, several noteworthy findings emerge from the estimation. The results underscore that the firms' export probability experiences an uptick with an increase in the scale of enterprises, as quantified by the number of permanent full-time employees. This is consistent with the conclusions drawn by Eck et al. (2015) and Exposito and Sanchis-Llopis (2020), who have corroborated the size effect on companies' propensity to engage in export activities. Compared to their smaller counterparts, firms with larger scale possess the financial capacity to undertake the higher sunk costs for export entry and the capability to implement more efficient manufacturing processes. Furthermore, a statistically positive relationship emerges between firms' labor productivity and their export decisions. To provide specifics, the probability of a firm engaging in exports increases by 0.02% with a 1% uptick in labor productivity. This result indicates that more productive firms exhibit a greater likelihood of participating in export activities, a trend aligning with the findings of Ha et al. (2021). The coefficients of the variables *Foreign_own* and *Foreign_ori*, which gauge firms' international

network, also yield statistical significance. This result implies that foreign linkages are pivotal in lowering firms' export entry barriers and elevating their propensity to engage in export activities. Moreover, the variables capturing enterprises' innovation intention and innovation ability exert a significantly positive influence on the probability of firms exporting, mirroring the findings of Doan et al. (2020).

In contrast, estimates reveal that firms' age and top manager's experience have no statistical effect on export decisions. This outcome aligns with the research conducted by Exposito and Sanchis-Llopis (2020).

4.2 | Robustness tests

4.2.1 | *U*-tests

The sign and significance of α_2 Equation (1) constitutes just one of the three crucial conditions required to establish the presence of U-shape relationships between the core explanatory variables and the explained variable (Assaf & Tsionas, 2019). Beyond assessing the sign and significance, the identification of the turning point's location and the determination of the curve's slopes are essential steps in this verification process. The *U-test* emerges as an intuitive and effective means to evaluate the turning point's location and the steepness of the curve (Zhang et al., 2023). The outcomes are presented in Table 7. The findings disclose that the curvilinear relationship undergoes a transformation when digital affordances attain a value of 0.700. The turning point is situated within the broader range of digital affordances, spanning from 0.035 to 2.245. Moreover, it is noteworthy that the slope at the lower end of the digital affordances is significantly negative, whereas the slope at the upper end is significantly positive. These outcomes decisively reject the null hypothesis, positing a U-shaped relationship. In light of these findings, it is substantiated that U-shaped relationships exist between digital affordances and firm-level export decisions.

4.2.2 | Alternative measure of digital affordance

In this section, we introduce an alternative measure of the core explanatory variable, digital affordances, recognizing that it is a multidimensional and intricate concept. This measure is employed to mitigate potential estimation biases, and we employ the entropy weight method for this re-evaluation. The entropy weight method has a well-established presence in comprehensive evaluation contexts dealing with multidimensional evaluation indices (Qu et al., 2022). This method assigns greater weight to indices with a pronounced influence in a comprehensive evaluation system. In Table 8, column (1) provides the results of the regressions involving the newly measured digital affordances, determined by using the entropy weight method, and their relationship with firm-level export decisions. The findings imply a statistically significant and positive quadratic effect, indicating the presence of a convex relationship between firm-level export decisions and digital affordances, as measured by entropy weight. We also use *U*-test to confirm this curvilinear relationship.

TABLE 7 The results of the *U*-test.

	Lower bound	Upper bound
Interval	0.035	2.245
Slope	−6.103	14.155
t-value	−10.594	5.328
$P > \|t\|$	0.000	0.000
Extreme point: 0.700		
Overall test of the presence of a U shape:		
t-value = 5.330		
$P > \|t\| = 0.000$		

TABLE 8 The estimation result of robustness tests.

	(1)	(2)	(3)
Variables	EX	EX	EX
DA	−27.184***	−6.410***	−7.289***
	(8.257)	(0.608)	(0.778)
DA2	44.254***	4.578***	5.244***
	(16.302)	(0.682)	(0.884)
Ln_scale	0.236***	0.234***	0.281***
	(0.033)	(0.034)	(0.043)
Ln_age	0.013	0.014	0.021
	(0.041)	(0.041)	(0.047)
Ln_exp	−0.015	−0.011	−0.009
	(0.030)	(0.030)	(0.036)
Ln_wage	0.072**	0.072**	0.077*
	(0.034)	(0.033)	(0.040)
Foreign_own	0.620***	0.625***	0.816***
	(0.085)	(0.085)	(0.097)
Foreign_ori	0.515***	0.516***	0.621***
	(0.114)	(0.113)	(0.128)
RD	0.284***	0.286***	0.352***
	(0.076)	(0.076)	(0.098)
Certificate	0.484***	0.485***	0.566***
	(0.058)	(0.058)	(0.072)
State		0.019**	
		(0.009)	
Constant	1.501	−3.296***	−3.971***
	(1.010)	(1.158)	(1.493)
Observations	5219	5219	5219
Country FE	YES	YES	YES
Industry FE	YES	YES	YES
Year FE	YES	YES	YES

Note: Robust standard errors in parentheses.
***$p < .01$.**$p < .05$.*$p < .1$.

4.2.3 | Incorporating control variable and modifying the model

Acknowledging that the omission of control variables in regression analyses may lead to biased or wrong results is imperative. In light of this concern, we introduce an additional control variable, the share of the state ownership (*State*), to enhance the robustness of our findings. The inclusion of the *State* variable aims to account for the firms' affiliations with government entities. Firms with stronger government connections are expected to exhibit heightened sensitivity to public policy dynamics (Ha et al., 2021). The regression results after incorporating the *State* variable are presented in column (2) of Table 8. Notably, the influences of digital affordances on firm-level export decisions remain statistically significant and align with the findings of the benchmark regression. This consistency reaffirms the validity and robustness of our regression findings.

Furthermore, to further validate the robustness of the benchmark regression results, we employ a robit model. The robust model is frequently introduced to address the impact of outliers on estimation results, a concern prevalent in the logit or probit model (Li et al., 2023). The robit model is obtained by replacing the normal distribution in the probit model with the student's *t* distribution (Roy, 2014). The utilisation of Student's *t* distribution accounts for heavy-tailed distributions, indicating reduced sensitivity of the model to outlying values (Barron, 2019). In our robit regression, we set the degree of freedom as 4. This setting is deliberate, as models with a lower degree of freedom demonstrate lower susceptibility to extreme sample data compared to those with a higher degree of freedom (Newson & Falcaro, 2023). The outcomes in column (3) of Table 8 affirm that the signal and significance of the robit regression coefficient associated with digital affordances in predicting firm-level export decisions are consistent with the benchmark regression outcomes.

Both sets of results, as shown in columns (2) and (3), are rigorously tested by the *U*-test, further underlining the robust nature of the observed U-shape relationships.

4.2.4 | Instrumental variable method

In this section, we use an instrumental variable as an efficient and vital approach to address the endogeneity issue. Following Angrist and Pischke (2009), we instrument the linear and quadratic terms of the endogenous explanatory variables separately. Specifically, we select the natural logarithm of the interaction term between home computer access in 2009 and the growth rate of the population using the Internet in each country during the survey year ($computer2009\_growth$) to instrument the linear component of digital affordances. Additionally, we employ the square term of $computer2009\_growth$ $\left(computer2009\_growth^2\right)$ to instrument the quadratic term of digital affordances. On the one hand, this choice is predicted on the rationale that digital affordances, as the extension of traditional communication technologies, can be influenced by recent developments in communication devices (Zhang et al., 2023). On the other hand, firm-level export performance is unlikely to be directly impacted by historical data pertaining to household-level communication devices, thereby satisfying the exogeneity requirement.

When addressing endogeneity in the context of a quadratic relationship, it is imperative to instrument both the linear and the quadratic components of the endogenous explanatory variable separately, utilizing additional instruments derived from the original instrumental variable. This approach is in consistent with the procedure advocated by Haans et al. (2016). Substituting the quadratic term of an endogenous variable with the quadratic term of the fitted value in the second stage of IV estimations may lead to inconsistencies because the linear term is not equivalent to the square of the linear term (Wooldridge, 2010). If an instrumental variable is suitable for addressing an endogenous explanatory variable, it is indeed prudent to employ both the IV and the squared IV to instrument both the linear and quadratic components of the endogenous variable (Angrist & Pischke, 2009).

Table 9 provides a comprehensive overview of the instrumental variable approach, encompassing the first stage, final regression results after introducing instrumental variables, and the outcomes of the weak identification test and under-identification test. Columns (1) and (2) showcase the results of the first stage regression, demonstrating that the instrumental variables significantly influence on both digital affordances and the quadratic term of digital affordances. This outcome affirms the correlation between the chosen instrumental variables and the core explanatory variables, thereby validating the rationality of our instrumental variable choices. Moving to the second stage of the regression, as presented in column (3), the influence of digital affordances on firm-level export decisions continues to exhibit statistical significance, reaffirming the presence of U-shaped relationships, consistent with the benchmark estimations. These results are tested by *U*-test, further supporting the robustness of the benchmark regression results.

Furthermore, we undertake the endogeneity and weak identification tests to evaluate the soundness of our instrumental variables, and the results of which are reported in lower section of Table 9. First, the Wald test for endogeneity yields a statistically significant χ^2 statistic, underscoring the potential endogeneity of digital affordances and its quadratic term, necessitating careful consideration within our study. Second, the LM statistics for the under-identification test yield significant statistics, suggesting the correlation of the instrumental variables. Lastly, both the AR and Wald statistics for the weak identification tests attain statistical significance, thereby rejecting the null hypothesis associated with weak instrumental variables. In summation, the selection of the instrumental variables is valid, and the U-shape relationship is robust.

4.3 | Mechanism analysis

A battery of robustness tests has been executed, validating the reliability of the benchmark findings. In the ensuing analysis, we delve into the moderating role of ambidexterity on the intricate nexus

TABLE 9 **TABLE** 9. Instrumental Variable Method Results.

	(1)	(2)	(3)
Variables	DA	DA^2	EX
computer2009_growth	−1.596***	−2.594***	
	(0.404)	(0.524)	
$computer2009\_growth^2$	−0.088	−0.458**	
	(0.125)	(0.171)	
DA			−5.120***
			(1.299)
DA^2			3.200**
			(1.387)
Constant	1.737***	2.661***	−2.074
	(0.051)	(0.067)	(1.505)
Observations	5235	5235	5219
Control variables	YES	YES	YES
Country FE	YES	YES	YES
Industry FE	YES	YES	YES
Year FE	YES	YES	YES
Wald test of endogeneity			5.91* [.052]
Under identification test (Kleibergen–Paap rk LM statistic)			64.54*** [.000]
Weak identification test (AR)			23.61*** [.000]
Weak identification test of (Wald)			23.60*** [.000]

Note: Robust standard errors in round brackets. The *p*-values are in square brackets.
***$p < .01$.**$p < .05$.*$p < .1$.

between digital affordances and firm-level export decisions, predicated on Equation (2). The initial examination of the influence mechanism of organizational ambidexterity is presented in column (1) of Table 10. The average marginal effects are expounded upon in column (2) to gain deeper insights. Subsequently, to rigorously verify the persistence of the U-shape nexus between digital affordances and firm-level export decisions in the presence of organizational ambidexterity's moderating influence, we subject our findings to scrutiny through the *U*-test.

While the interaction terms, $DA_{it} \times ambi$ and $DA_{it}^2 \times ambi$, exhibit statistical significance, it is important to note that the significance of coefficients β_3 and β_4 in Equation (2) neither constitute necessary nor sufficient conditions to affirm the presence of moderation effects within a nonlinear specification (Haans et al., 2016). Therefore, the nuanced aspects of moderation effects, encompassing the turning point moderating effect and the flattening or steepening moderating effect, demand further exploration, guided by the methodologies espoused by Haans et al. (2016) and Assaf and Tsionas (2019).

H2 posits that the firms' organizational ambidexterity shifts curve's turning point to the left. To verify H2 and derive policy and managerial implications, we conduct the tests to examine the shift of the turning points induced by the moderating influence of a firm's organizational ambidexterity. We inspect these variations by detecting the signal of $\alpha_1\alpha_4 - \alpha_2\alpha_3$ in Equation (5) for the firms exhibiting organizational ambidexterity. Our findings reveal a negative sign for $\alpha_1\alpha_4 - \alpha_2\alpha_3$, signifying that the turning point shifts to the left in the context of a moderation effect. Furthermore, we formally evaluate whether Equation (5) as a whole significantly deviates from zero by assigning meaningful values to the moderator variable. Specifically, we define organizational ambidexterity at its mean ($ambi = 0.36$) as the middle level, with 0.23 standard deviation below and above its mean, representing the low level and high level, respectively. Figure 2 graphically illustrates the movement of the turning points. The results demonstrate that the turning points shift to the left with a higher level of ambidexterity. The shift from low level to high level of organizational ambidexterity is statistically significant ($Z = -2.15$, $p < .05$ for ambidexterity at −0.23 standard deviation; $Z = -2.00$, $p < .05$ for ambidexterity at mean value; $Z = -1.91$, $p < .10$ for ambidexterity at +0.23 standard deviation). These results corroborate H2, indicating that a firm's organizational ambidexterity moderates the U-shaped nexus between digital affordances and firm-level export decisions by repositioning the equilibrium point towards lower levels of digital affordances. That is to say, this result indicates that firms exhibiting higher levels of organizational ambidexterity encounter a lower threshold of digital affordances required to make positive export decisions.

H3 posits that firms' organizational ambidexterity steepens the curvilinear relationship proposed in H1. To investigate this, we examine the slopes at a specified distance "*a*" (where *a*>0) from the turning points to the right side and report these slopes through graphical representations. For the sake of simplicity, we compare these slopes at low, middle, and high levels of ambidexterity. Figure 3 confirms organizational ambidexterity's steepening effect, as the line is significantly steeper at higher levels of ambidexterity than at lower levels, aligning with H3.

TABLE 10 Influence mechanism results.

	(1)	(2)
Variables	EX	Marginal effects
DA	−7.729***	−1.815***
	(0.846)	(0.153)
DA^2	5.482***	1.360***
	(0.762)	(0.181)
DA × ambi	2.799**	
	(1.221)	
DA^2 × ambi	−1.351**	
	(0.566)	
ambi	−0.278	0.143*
	(0.403)	(0.074)
Constant	−3.679***	
	(1.130)	
Observations	5219	5219
Control variables	YES	YES
Country FE	YES	YES
Industry FE	YES	YES
Year FE	YES	YES

Note: Robust standard errors in parentheses.
***p < .01.**p < .05.*p < .1.

4.4 | Further analysis

Up to this juncture, the paper has primarily centered on examining the nexus between digital affordances and the extensive margin of export. The subsequent segment advances our analysis by shifting our attention towards investigating the intricate nexus between digital affordances and the intensive margin of trade. In this context, we gauge the intensive margin of trade using the export share, computed as the percentage of firm-level total sales attributed to sales exported directly and indirectly (Kul Kapri, 2019). Employing ordinary least squares regression, we reconfigure Equation (1), replacing firm-level export decisions with export share as the explained variable. The results of this estimation, elucidating the impact of digital affordances on the firm-level intensive margin of export, are reported in column (1) of Table 11.

Subsequently, we delve deeper into the relationship between firm-level intensive margin of export and the influence of digital affordances by deploying a fractional probit model. This modeling choice is apt, considering that firms' export share varies between zero and one. The estimation outcomes are reported in column (2) of Table 11, offering compelling evidence of a U-shaped nexus between digital affordances and firm-level intensive margin of trade.

To this end, there are still concerns regarding potential selection bias (Heckman, 1979), given that exporting firms may exhibit a higher level of productivity, consequently garnering a larger share of total sales. We introduce two-step estimation approach of Heckman (1979) to mitigate the bias in selection. The Inverse Mill Ratio (IMR) is computed based on the corresponding probit estimation and subsequently incorporated as a regressor into the regression model, which assesses firms' intensive margin of trade in relation to digital affordances. The outcomes of this analysis are documented in column (3) of Table 11. The statistically significant coefficient of IMR attests to the existence of selection bias. Importantly, the results consistently corroborate the existence of a U-shaped nexus between digital affordances and firms' intensive margin of trade.

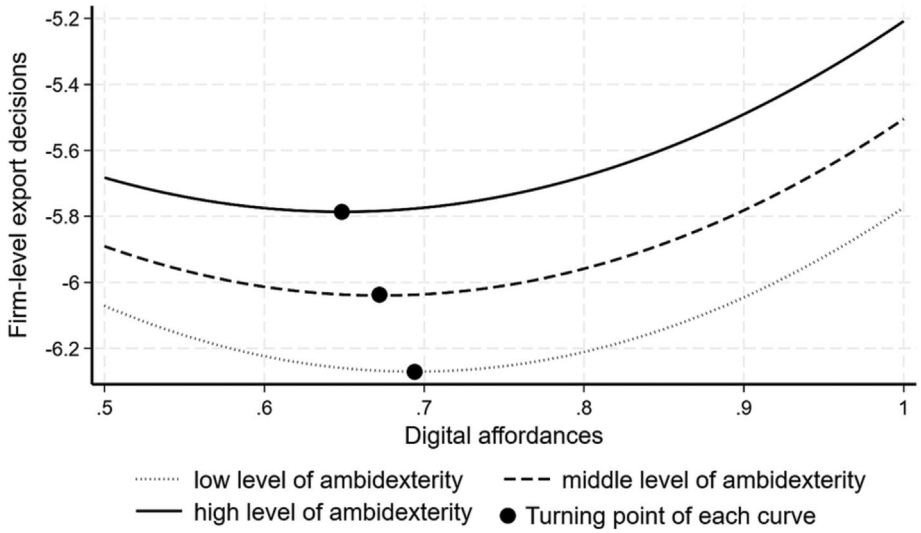

FIGURE 2 The moderating effect of ambidexterity on digital affordances and export decisions.

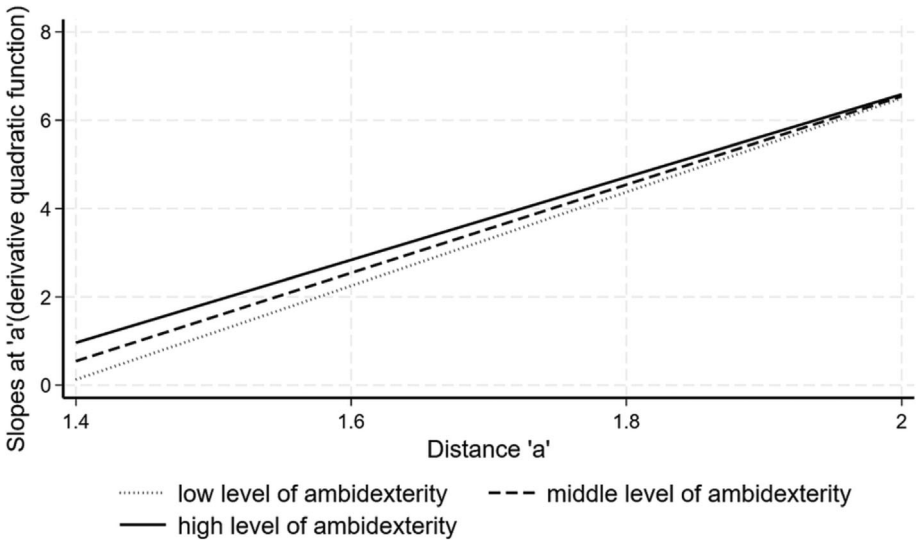

FIGURE 3 Analysis of the slopes from the turning point at distance "*a*".

TABLE 11 Estimation results of further analysis.

	(1)	(2)	(3)
Variables	OLS	Fractional probit	Heckman
DA	−0.629***	−2.255***	−1.671***
	(0.105)	(0.423)	(0.366)
DA^2	0.448***	1.657***	1.229***
	(0.109)	(0.432)	(0.291)
IMR			0.276***
			(0.087)
Constant	0.045	−2.307***	−0.492*
	(0.146)	(0.659)	(0.263)
Observations	5227	5227	5218
R-squared	0.379		0.387
Control variables	YES	YES	YES
Country FE	YES	YES	YES
Industry FE	YES	YES	YES
Year FE	YES	YES	YES

Note: Robust standard errors in parentheses.
***$p < .01$.**$p < .05$.*$p < .1$.

As displayed in Table 11, the coefficient of digital affordances (DA) concerning export share is observed to be negative, while the coefficient of DA^2 is positively signed. These findings signify that the firm-level intensive margin of trade initially decreases and subsequently increases with improved digital affordances. These estimations have undergone rigorous validation through *U*-tests, firmly substantiating the presence of a convex relationship between digital affordances and firms' intensive margin of trade. This dynamic is characterized by digitalization's potential to diminish export costs, decrease transaction times, and enhance the quality of logistic services and transport infrastructure. Simultaneously, sustaining export growth necessitates a continuous and unwavering commitment to the process of digitalization (Nham et al., 2023).

5 | CONCLUSION AND DISCUSSION

5.1 | Conclusion

By merging the international sample of 19 OECD countries and firm-level data from WBES covering the period starting from 2010 to 2020, this study offers valuable insights into the complex connection between digital affordances and firm-level export performance. First and foremost, aligning with earlier research (Barbieri et al., 2022; Elia et al., 2021; Zhou et al., 2022), our findings underscore the paramount significance of digital technologies, platforms, and infrastructures in elucidating firms' export performance dynamics. However, in contrast to the prevailing consensus that has predominantly portrayed this relationship as positive and linear (Mu et al., 2020), our investigation unveils a U-shaped association between digital affordances and both the extensive and intensive margins of firm-level export. Embracing the tenets of the curvilinear relationship approach (Haans et al., 2016), this nonlinear U-shaped nexus between digital affordances and firm-level export performance implies that positive effects manifest only once digital affordances have matured to a specific threshold. Second, our analysis also reveals that this U-shaped relationship is accentuated in the presence of higher levels of firms' organizational ambidexterity. Organizational ambidexterity serves to amplify the positive linkage between digital affordances and firm-level export decisions. This augmentation occurs because firms endowed with a higher level of ambidexterity exhibit heightened adaptability to the volatile environment, a greater propensity for resource exploitation, and the capacity to seamlessly harmonize both exploitative and explorative innovation endeavors.

5.2 | Theoretical contribution

This research provides several potential contributions by delving into the intricate relationship between digital affordances and firm-level

export performance while simultaneously introducing the pivotal role of organizational ambidexterity as a contextual factor. First, it provides a nuanced and comprehensive explanation of the role of digitalization as a precursor to export performance. While previous studies have highlighted the influence of digitalization on firms' internationalization and export performance (Caputo et al., 2022; Jean & Kim, 2020), this body of literature has traditionally propagated a "more is better" narrative. However, we advance a novel perspective by postulating a U-shaped nexus between firms' export performance and the impact of digital affordances. This conceptualization emerges from a multiplicative fusion of two latent underlying mechanisms: positive influence and negative influence. Positive influence encompasses the beneficial effects of digitalization on a firm's export endeavors, encompassing aspects such as the declination of transaction costs and the refinement of production processes. In contrast, negative influence encompasses the hindrances encountered while striving to enhance digital affordances, referring to factors such as the threshold effect of digital affordances, the misalignment between a firm's digital transformation efforts and its managerial capabilities and business environment, and the initial investments required to actualize digital transformation. The multiplicative combination of the positive and negative influence results in the U-shaped nexus between digital affordances and firm's export performance.

The second noteworthy contribution of this work aligns with the expanding body of research highlighting the contextual nature of organizational ambidexterity. Specially, we posit that ambidexterity serves as a moderating force in the relationship between firms' export performance and the impact of digital affordances. We argue that firms overly reliant on either exploitative or explorative strategies tend to exhibit a reduced inclination to venture into new markets. This is primarily due to the limitations inherent in such strategies: the former lacks the agility to acclimatize rapidly transforming environments (Uotila et al., 2009), and the latter often misestimates the risks and costs of failure (Assink, 2006). We posit that the harmonious fusion of exploitative and exploratory innovation is imperative to offset these risks, as firms could glean benefits from novel routines within international markets while harnessing their existing resources concurrently (Yan et al., 2021). Our research has extensive significance for ambidexterity research, shedding light on its multifaceted role. Ambidexterity is not only an antecedent of organizational performance (Aljumah et al., 2021; Lee et al., 2015) or an outcome of digitalization (Åkesson et al., 2018; Park et al., 2020) but also serves as a contextual advantage that reinforce the potential advantages of digital affordances in the context of firms' export performance.

5.3 | Practical implications

This study underscores several pertinent practical implications. It firmly establishes that developing digital affordances is a pivotal avenue for reducing transaction costs, enhancing production processes, and consequently, facilitating firms' export performance. Therefore, our findings suggest that all countries accord high priority to fostering the growth of digital affordances and should persist in their investments in digital technologies. An optimal threshold of digital affordances exists, beyond which the appreciation of export performance commences. Digitalization possesses the potential to augment firms' export performance ultimately. Consequently, concerted efforts can be made to refine digital platforms, catalyze technological innovations, and fortify digital infrastructures to fully harness digital affordances' favorable potential.

An additional consequential implication for managers within firms pertains to the involvement of organizational ambidexterity in the nexus between digital affordances and firms' export performance. Our study reveals that firms exhibiting a higher level of ambidexterity have a lower threshold for making export decisions, indicating a proactive stance in international market entry, as opposed to firms with a lower level of ambidexterity. Moreover, digital affordances have the potential to amplify the positive influence of digital affordances on firms' export performance. Hence, our recommendation for managers aspiring to reap the revenues and benefits of international markets is to nurture and perform a long-run plan for cultivating and deploying organizational ambidexterity.

5.4 | Limitations and future research

Despite the potential contributions provided by this study, it is important to realize its inherent limitations. First, our research design employs a pooled cross-sectional approach, which prevents a comprehensive analysis of causal relationships over time. Second, digital affordances and organizational ambidexterity measures are somewhat constrained due to data availability. The incorporation of more objective indicators would enhance the robustness of our findings. Third, the empirical results were drawn from firm-level samples from 19 OECD countries, predominantly consisting of developed countries. It is imperative to account for the influence of digital affordances on export performance within developing countries, where digital infrastructure and digital platforms may be less robust. Future studies could explore alternative data sources to obtain more reliable facts of developing countries. Fourth, our analyses are conducted at the firm level, leaving room for further examination of the relationship between digital affordances and export performance at the industrial level.

Future research directions may also involve an exploration of the influence of digital affordances on other dimensions of export performance, such as export quality, product diversification in exports, and firms' internationalization strategies. Furthermore, it is plausible that additional avenues exist through which digitalization impacts exporting performance. Factors such as government policies and business models could be integrated into future research as moderating variables within the intricate relationship between digital affordances and export performance.

AUTHOR CONTRIBUTIONS

László Erdey conducted the preliminary study, led the literature review, contributed to the discussion, and responsible for the proofreading.

Laisha Liu participated in the preliminary study, contributed to the literature review, data collection and analysis, and discussion.

Adrián Nagy focused on the literature and conducted the data analysis.

CONFLICT OF INTEREST STATEMENT

The authors have no relevant financial or non-financial interests to disclose.

DATA AVAILABILITY STATEMENT

Raw data to measure the explanatory variable were generated at OECD Statistics. Derived data are available from the corresponding author on request. The data regarding control variables, explained variables, and the measurement of moderating variable are available from the World Bank's Enterprise Survey (WBES). Data are available with the permission of WBES.

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