Gender and Access to Bank Credit Around the World During the COVID-19 Pandemic: The Mediating Role of Digital Transformation

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Abstract

Drawing on the rich firm-level enterprise survey dataset of more than 58,000 small enterprises in 39 developing and emerging economies, this study investigates gender disparities in firms' financial fragility, credit demand, and credit provision during the COVID-19 pandemic, and the role of digital transformation in addressing these disparities. We used a probit model with selection and an instrumental variable approach to account for the selection effects and endogeneity of the female ownership and leadership measures. Furthermore, several robustness checks are used to account for endogeneity problems caused by omitted variables and self-selection bias. These econometric tests were conducted using STATA software. We find that female-led businesses are more vulnerable to the negative effects of the pandemic and have higher demand for credit. However, they are less likely to request loans (credit self-rationing) and more likely to be denied credit when applying for bank credit. This gender bias in credit provision is exacerbated by the pre-pandemic financial constraints on female-led enterprises. This study also tested the mediating role of a firm's technology adoption and digital transformation in credit access. The results of the mediation analysis show that female-led enterprises that adopted e-commerce and remote work technologies during the pandemic had better access to bank credit than other firms, suggesting that digital transformation significantly enhanced female-led businesses' access to bank credit and narrowed gender disparities in the credit market in times of extreme financial and economic distress.

Keywords: Digital transformation, e-commerce, gender and bank credit access, financial constraints, borrower discouragement, financial inclusion.

1. Introduction

The social, economic, and financial impacts of the COVID-19 pandemic on national economies and businesses have been well-documented globally. One of the stylized facts is that female workers as well as female-led businesses suffered disproportionately due to the unprecedented, gendered implications of the crisis (e.g., Birhanu, Getachew, & Lashitew, 2022; Liu, Wei, and Xu, 2021; Njiwa et al., 2023; Elouardighi & Oubejja, 2023; Wu, 2022). Financial distress and liquidity shortfalls are important factors influencing the impact of the COVID-19 pandemic on business performance and financial vulnerability (Goldstein et al., 2022; Leng & Sun, 2024). Firms with credit access difficulties before the pandemic were more likely to have liquidity issues, sales declines (Zhang & Sogn-Grundvåg, 2022) and restricted investments in new technologies to adjust their production and business operations (Khan, 2022). Prior studies also show that female-led businesses are disadvantaged by discriminatory "gendered ascriptions" and experience greater difficulties in accessing external finance (De Andrés et al., 2021; Marlow & Patton, 2005). Gender-based discrimination can lead to misallocation of credit and, consequently, inefficiencies in financial markets (Beck et al., 2018), which may have a negative impact on the growth and survival of small businesses, employment, and ultimately, the economy at large. However, evidence of the economic consequences of the COVID-19 crisis on female-led businesses and how this has affected their demand for and access to finance is limited and less documented. This study addressed three interrelated research questions. First, we examine gender differences in financial fragility and the demand for and supply of external financing during the COVID-19 pandemic. Women tend to have greater propensity for risk aversion (Meyll & Pauls, 2019) which may exacerbate during extreme economic uncertainty such as the COVID-19 pandemic. This may constrain their demand for bank credit during economic downturns (Cowling, Marlow, & Liu, 2020). Second, we investigate whether female-led businesses have greater tendency not to apply for bank credit due to the prototypical feminized risk aversion. Third, we investigate whether gender differences in firms' loan demand and supply varied over time during the pandemic.

The COVID-19 pandemic has exacerbated financial constraints (Balduzzi et al., 2020), affecting credit-constrained firms' investments and limiting their access to digital technologies and platforms (Khan, 2022). These are vital for ensuring continuity in business operations in the face of lockdowns, mobility restrictions, and workplace closures. The adoption of Internet technologies and digital transformation (DT) might have provided digitalized businesses in the during-COVID period with a competitive edge by positioning them for growth through access to wider segments of consumers through cost-effective supply chains (Brem et al., 2021), thus enhancing their resilience in navigating the pandemic-induced economic crisis. Digitalized small and medium-sized enterprises (SMEs) can benefit significantly from increased customer interactions and market access,

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especially those facing financial and market access restrictions (Markovic et al., 2021). Technological advancements and digital transformation have made financial resources more accessible to SMEs, lowered barriers, and improved financing and investment efficiency (Cui & Wang, 2023; Li & Xu, 2023). Thus, we also examine the mediation effect of digital transformation on women-led firms' access to bank credit during the COVID-19 pandemic.

We draw on the data from the World Bank's pre-pandemic Enterprise surveys (WBES) and the ongoing follow-up "Covid-19 impact surveys (COV-FS)" covering more than 58,000 enterprises across 39 developing and emerging economies, 93% of which are SMEs. We utilized the COV-FS data for the first four waves conducted between May 2020 and August 2021. The empirical findings of this study show that female-led enterprises typically require more financing because they experience greater financial difficulties than male-led enterprises, consistent with recent empirical findings (e.g., Elouardighi & Oubejja, 2023; Njiwa, Atif, Arshad, & Mirza, 2023). They are less likely to apply for bank loans, have higher rejection rates than male-led firms, and have lower propensity for bank financing. These findings are further exacerbated by the pre-pandemic credit access difficulties experienced by female-led businesses. Furthermore, female-led enterprises have higher incidences of credit self-rationing and financial fragility. Finally, the mediation analysis shows that technology diffusion and digital transformation reduce gender disparities in financial access and fragility, resulting in better access to financial resources for digitalized female-led enterprises than for other businesses.

This study contributes to the literature in three ways: First, to the best of our knowledge, this is among the first to provide new evidence of the mediating role of technology adoption and digital transformation in reducing gender gaps in SMEs' access to financial resources during the COVID-19 pandemic. Digital transformation has helped SMEs reduce the negative effects of the COVID-19 pandemic and has led to the growth of digitalized SMEs (Zia et al., 2023). Firms that leverage digital platforms through technology diffusion, digital marketing, and innovation achieve higher levels of success and profitability during crises (Rojas-García et al., 2024). Digital inclusion also reduces the gender gap in labor force participation (Mohieldin & Ramadan, 2024). Furthermore, digital transformation promotes financial inclusion by reducing the cost of financial intermediation (Cui & Wang, 2023; Skare et al., 2023). It also helps alleviate liquidity constraints by facilitating supply chain financing through digital platforms (Chen et al., 2021). This study's findings support the notion that digital transformation benefits female-led enterprises by fighting the pandemic's negative consequences and positioning them for better access to external financing. These results imply that women-led enterprises may gain from leveraging their organizational resources to enhance access to funding by embracing digital transformation in their management, production processes, and business models to adapt to changing circumstances.

Second, a broad body of literature has predominantly investigated gender differences in credit access during normal economic periods (e.g., Bertrand & Perrin, 2022; Chundakkadan, 2023; Nyarko, 2022; Wellalage & Locke, 20217). However, further studies are needed to explore gender disparities in financial access from the perspective of dual economic risks during the COVID-19 pandemic, particularly from the perspective of small businesses operating in developing and emerging markets. This study is the first to examine whether firm-level pre-pandemic external financing difficulties exacerbate the consequences of the COVID-19 crisis on women-led firms' access to financing. Khan (2022) found that firms with pre-pandemic financing constraints were more vulnerable to greater liquidity shocks and credit risk during the COVID-19 crisis. Aristei and Gallo (2023) examined how green management practices and pre-pandemic financial conditions affected the impact of the pandemic on firms' credit access. We contribute to this growing (but limited) strand of the literature by examining whether prior external financing constraints have a differential impact on gender disparities in financial fragility and access to finance for women-led enterprises. We consider multiple indicators of financial constraints (e.g., credit demand, loan application behavior, supply of debt finance, and bank discouragement). This study is the first to examine pre-pandemic firm heterogeneity in credit constraints and perceived financial obstacles, thereby providing robust evidence of gender disparities in the credit market in the context of adversity and exogenous economic shock.

Third, in a first, this study examines the effect of gender on the demand-side credit constraints by exploring gender differences in borrower discouragement during a unique economic crisis. This is crucial in designing policies for vulnerable businesses. This study documents significant disparities in the impacts on female-led firms across regions and over time using the panel aspects of a dataset covering four rounds of COVID-19 follow-up survey datasets from May-2020 to August-2021. The global context provides an analysis of the "contextual" nature of the female leadership-finance access relationship, considering the economic, institutional, and cultural differences between developing and emerging countries.

2. Theory and Hypotheses

2.1 Gender, Entrepreneurship, and Finance Access

Gender is a key identity marker that creates mutual understanding between human subjects (Butler 2004), with stereotypical feminine traits associated with femininity viewed as having lower values (Bowden & Mummery, 2014). In entrepreneurship, the preferred entrepreneurial profile mirrors masculine characteristics, creating a "masculinized discourse" that disadvantages women and privileges men (Marlow et al. 2008). While studies find no inherent entrepreneurial weakness attributable to gender, gendered ascriptions impede women's ability to accumulate entrepreneurial capital and legitimacy (Robb & Watson, 2012), resulting in fewer women starting businesses because of structural and tacit discrimination. Female entrepreneurs often exhibit higher risk aversion (Faccio,

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Marchica, & Mura, 2016), leading to lower demand for bank credit and a higher reluctance to take on debt (Cowling, Marlow, & Liu, 2020). This results in a scenario in which women rely on informal financing sources, whereas those seeking external financing are more cautious because of their feminine risk aversion. Banks restrict lending to marginal borrowers, particularly during financial crises, resulting in more severe credit contractions in female-led enterprises (Cesaroni et al., 2013).

Previous studies have shown that women-owned firms are more credit constrained in the formal loan market than male-owned firms despite the increasing share of women-owned businesses (Faccio et al., 2016; International Labour Office, 2019). The literature proposes three main theories that describe gender-based discrimination in credit markets. This is discussed briefly below.

Statistical discrimination: As the demographic characteristics of loan applicants may be related to the unobservable quality of creditworthiness (Arrow, 1973), the lender may be tempted to use the loan applicant's gender to infer creditworthiness. Thus, if women borrowers, on average, are more likely to default on their loan, the loan officer might apply to certain women-owned businesses the average quality of funded women-led businesses in order to minimize costs pertaining to collect more borrower-specific information. Bellucci, Borisov, and Zazzaro (2010) suggest that the generally lower proportion of women-owned businesses in the economy makes the availability of information about these firms limited and less reliable, rendering access to formal credit markets for creditworthy female businesses more difficult and thus affecting the firm's development and growth.

Taste-based discrimination: Becker (1957) pioneered this theory and proposed that economic agents prefer not to engage in financial transactions with members of discriminated groups because of prejudice or bias, even at the expense of financial losses. Taste-based gender discrimination is rooted in a person's preferences and cultural beliefs about a particular gender, which may influence financial institutions when formulating judgments about loan applications. Such discrimination will occur if loan officers responsible for approving credit inherently have antipathy towards female loan applicants (prejudiced) and prefer to avoid commercial relationships, even if they imply forgoing potentially profitable commercial transactions to avoid indulging with members of the discriminated group. In the presence of some degree of taste-based discrimination, female borrowers face higher credit constraints such as being offered less credit, experiencing higher loan rejection rates, and higher financing costs, although the circumstances may otherwise be similar for male and female borrowers. Thus, we propose the following hypothesis:

> ➢ *H1: Financial institutions are more likely to reject loan requests by female entrepreneurs because of gender prejudice and because they typically lack the resources needed to serve as collateral for bank loans. This higher likelihood of loan rejection also increases during times of financial and economic distress such as the COVID-19 pandemic.*

Variations in borrower characteristics and preferences for debt financing between women-led and men-led enterprises may also play a role in the origin of gender inequalities in access to bank credit (Muravyev et al., 2009; Rizwan & Khan, 2007). Thus, gender disparities in the demand for external funding may reflect both differences in financial needs and the perception of the likelihood that a loan will be approved or denied, which may influence bank discouragement. According to a distinct stream of literature, women-led firms tend to abstain from applying for bank loans because they typically feel less confident about their capacity to negotiate loan terms with banks and financial institutions (Croson & Gneezy, 2009) and, consequently, refrain from requesting credit and exhibit discouraged borrowing behavior (Naegels, Mori, & D'Espallier, 2022). Other studies note that women-led businesses also refrain from raising funds through equity markets, as they prefer to finance investments through internal sources (Brush et al., 2018) or informal sources, such as networks of friends and family. Consequently, female-led businesses face major resource constraints compared to their male counterparts (Kogut & Mejri, 2022) because of smaller equity capital, reduced access to external equity financing (Brush et al., 2019), and bank credit (Wellalage & Thrikawala, 2021). Hence, they rely more on personal, family, and informal resources than on formal financing channels. Furthermore, negative shocks such as financial crises can impact people's risk attitudes. Risk aversion is more common among female entrepreneurs, which may limit their need for financing (Aristei & Gallo, 2016; Jetter et al., 2020; Meyll & Pauls, 2019). As the COVID-19 pandemic has disproportionately affected female-led businesses (Mustafa et al., 2021), it is expected that female entrepreneurs' propensity for risk aversion will worsen during these times (Li et al., 2021), which can influence their demand for bank credit. Drawing on the theoretical elements of risk aversion theory and resource dependency theory, we formulated the following hypothesis:

> ➢ *H2a and H2b: Because of their generally lower risk tolerance and reluctance to incur debt finance during economic and financial distress, female entrepreneurs are more likely to have a lower demand for bank credit (H2a) and, therefore, less likely to apply for credit to meet their liquidity and financing needs (H2b).*

2.2 Financing Constraints and Firm-level Financial Vulnerabilities During COVID-19 Crisis

The COVID-19 pandemic has exposed firm vulnerabilities, particularly financial constraints, which have been exacerbated by the pandemic (Khan, 2023). Studies show that pre-pandemic financing constraints lead to severe liquidity problems and delinquency and hinder digital transformation efforts (Aristei & Gallo, 2023). Khan (2022) demonstrates how pre-pandemic credit constraints worsen both the credit risk and liquidity issues caused by the pandemic. Analogously, Aristei and Gallo (2023) find that pre-pandemic credit constraints exacerbate economic and financial vulnerabilities and intensify firm-level financial distress and liquidity problems. They further argue that credit-constrained businesses not only have a higher likelihood of experiencing liquidity shortfalls or having

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difficulties making repayment issues with their financial obligations but also have a harder time obtaining bank funding. Firms with better credit access before the pandemic are less likely to experience a decline in sales (Amin & Viganola, 2023). Credit constraints exacerbate economic and financial vulnerabilities, making it difficult for businesses to obtain bank financing and meet their financial obligations. Balduzzi et al. (2020) find that credit-constrained businesses have pessimistic expectations and plans to reduce investment, suggesting that financial constraints exacerbate the crisis's negative effects. Thus, we formulate the following hypothesis:

➤ *H3: Pre-pandemic financing constraints worsened gender-based credit market disparities and pandemic-induced financial fragility in female-led businesses during the COVID-19 crisis.*

2.3 Gender and Access to Finance: The Mediating Role of Digital Transformation Channel

The digital economy has developed rapidly, leading to increased productivity, firm growth, financial performance, and corporate resilience (Xia et al., 2022) and closing gender disparities in female labor participation (Mohieldin & Ramadan, 2024). Digital transformation enables resource-constrained enterprises to reach national and international markets cost-effectively (Yu et al., 2022), facilitates efficient information flow, accelerates innovation, and assists in corporate transformation (Fitzgerald et al. 2014). However, barriers to widespread adoption include the slow diffusion of technologies, lack of financial resources, technical expertise, organizational inertia (Khan, 2022b), and understanding of technology adoption (Adomako et al., 2021). The COVID-19 crisis has prompted many SMEs to adopt digital technologies and platforms to adapt to changing customer needs and improve their resilience. Furthermore, digital transformation (DT) enhances financial inclusion by enabling efficient financial transactions and alleviating liquidity issues (Skare et al., 2023). This also increases a firm's access to working capital and short-term financial requirements (Chen et al., 2021). Thus, we formulate the following hypothesis:

➤ *H4: Female-led firms that adopted DT during the COVID-19 crisis have better access to bank financing.*

3. Data Description and Methodology

3.1. Data Description

The empirical analysis in this study used two survey datasets: the pre-pandemic World Bank Group Enterprise Survey (*WBES*) and the Covid-19 Impact Follow-up Survey (*COV-FS*), conducted in four waves after the onset of the COVID-19 pandemic using the same sample of firms from the baseline *WBES*. The pre-pandemic *WBES* collected firm-level data from registered private businesses across countries, focusing on business environment, performance, and characteristics. The *COV-FS* dataset evaluates the economic effects of the pandemic on private businesses using telephone interviews to calculate indicators such as business closures, operations, employment, revenue, access to external financing, and

policy initiatives. Both datasets provide comparable data across countries. The *COV-FS* surveys were conducted in these countries over the course of three waves, between May and June 2020 and August and September 2021. The *COV-FS* dataset offers precise indicators of the various effects of the COVID-19 pandemic on businesses, similar to the *WBES* dataset for firm outcomes in the pre-pandemic period. The information acquired during these surveys was used to calculate a range of indicators, including business closures, operations, employment, revenue, workforce changes, finances, gender, policy responses, and expectations to determine the impact of the crisis on a firm's performance metrics.

The *WBES* reflects the pre-crisis situation because it was completed before the COVID-19 pandemic began. Thus, the pre-pandemic data from the *WBES* served as a baseline for *COV-FS* indicators for comparison. The *WBES* collects firm-level data from a representative sample of officially registered private businesses with five or more employees in retail, manufacturing, and service industries. *WBES* data are comparable across countries owing to the use of a global methodology based on stratified random sampling. The *WBES* collects information on various components of the business environment, firm performance, and firm characteristics, including the gender of the firm's top manager and the percentage of female and male ownership.

3.2 Female Ownership Variables

We constructed two variables that accounted for the gender of business owners and highest-ranked manager. Following Aristei and Gallo (2016), the first dummy variable (*FEM-LED*) equals one if the top manager of a firm is a woman and there are one or more female owners. This binary variable accounts for women's involvement in both business ownership and management. The second dummy variable (*FEMALE-OWNED*) equals one if women's ownership is 51 percent or more; hence, it measures the extent of female ownership. These variables provide a nuanced analysis of a firm's financing demand and supply by gender. Of the firms in the sample, 32.3% had at least one woman among the firm's owners and 17.67 percent had a female top manager.

3.3 Econometric Specifications

3.3.1 Probit with Selection Model

This study explores gender differences in firms' loan application decisions, financial access, and borrower bank discouragement behaviors during periods of economic uncertainty. Hence, we developed several research objectives to examine how gender affects the ability of women-owned businesses to apply for and obtain external financing during the COVID-19 pandemic. Several dependent variables were constructed, each sought to address a specific research question. First, we hypothesize that the pandemic affected financing needs differently for women-led businesses, as they have been disproportionately affected and suffered deeper financial distress (Amin & Viganola, 2023). We aim to understand the impact of gender differences on firms' external financing

needs by employing a *probit with a selection model* that accounts for selection effects at the credit demand stage.

$$Prob(Cred\_Demand_{jkct}) = \beta_i X_{jkct} + \gamma FEM\_LED_{mkct} + D_{ct} + \varepsilon_{mkct} \qquad (1)$$

Selection equation:

$$Prob(Liquidity\_Decreased_{jkct}) = \beta_i X_{jkct} + \gamma FEM\_LED_{mkct} + \partial Z_{jkc} + D_{ct} + \varepsilon_{mkct} \qquad (2)$$

Following Khan, Khan, & Ullah (2021), this study identifies firms with financing needs using a loan demand dummy variable, *Cred_Demand*, which equals one if (a) applies for a bank loan or (b) chooses not to apply because of tough lending conditions (e.g., high interest rate, higher collateral requirement) or fear of loan-application rejection. *Cred_Demand* equals zero for other non-applicant firms that stated "*sufficient funds*" as the reason they chose not to submit loan applications. The subscript *j* denotes the *jth* firm in the *kth* industry at *2-digit ISIC Code 3.1* in country *c*. *Dct* denotes dummy variables for waves one–four of the *COV-FS* follow-up surveys during the COVID-19 pandemic. These dummy variables account for the different months of data collection for the *COV-FS* waves across countries. Following prior literature on similar research (Allison et al., 2023; Beck et al., 2005; Liu, Wei, & Xu, 2021; Abdullah, Shah, & Khan, 2012), X_{jkct} is a set of firm-level control variables such as firm size (three dummies: *small (fewer than 20 employees), medium-size (20<employees <99), large (employees>99)*), age (natural Logarithm), export status (*exporter*), foreign ownership (*Foreign*), and industry dummies were also used as controls in the econometric specifications. Furthermore, the pre-pandemic proportion of working capital financed from internal funds (*WC Finance*) and sales growth (*Sale Growth*) were also included in the regressions to account for pre-pandemic financial access and firm performance. The inclusion of pre-pandemic firm-level sales growth accounts for potential pre-pandemic gender disparities in firm performance (Birhanu et al., 2022). Furthermore, Government financial support (*Govt Asst*) accounts for government subsidies during the pandemic (Mascia & Rossi, 2017). The inclusion of this binary variable (*Govt Asst*) aims to allay concerns that differences in a firm's access to bank funding are caused by government subsidies intended by policymakers to correct any bias or market failure, rather than accounting for the effects of the entrepreneur's gender (Mascia & Rossi, 2017). The country dummies account for cross-country variations in economic and institutional contexts (Khan & Rizwan, 2020; Shah et al., 2017). The main coefficient, lambda, captures gender-based differences in external finance demand during the pandemic.

Three variables were constructed from the *COV-FS dataset*: (1) Liquidity *Decreased* (Eq. 2) equals one if a firm experienced a cash flow shortfall and zero otherwise. (2) *Demand Decreased* equals one if the demand for a firm's products and services decreased, and zero otherwise. (3) *Sale Change* is the percentage change in monthly sales compared to the previous year. The last two variables serve as instrumental for *Liquidity Decreased* variable in Eq. (2), which is represented by ∂Z_jkc.

Second, the following probit model with selection was employed to account for selection effects at the loan application stage for bank credit access.

$$Prob(Finance_{jkct}) = \beta_i X_{jkct} + \gamma FEM\_LED_{mkct} + D_{ct} + \varepsilon_{mkct} \tag{3}$$

Selection equation:

$$Prob(APPLY_{jkct}) = \beta_i X_{jkct} + \gamma FEM\_LED_{mkct} + \partial Z_{jkc} + D_{ct} + \varepsilon_{mkct} \tag{4}$$

X_{jkct} represents the firm characteristics, as defined in Eq. (1). The dummy variable, *Finance*, represents access to bank credit during the COVID-19 pandemic. Following Aristei and Gallo (2023), we introduced a strictly exogenous dummy variable (*business obstacles*) in the selection equation. It measures a firm's perception of significant obstacles to business operations, such as licensing, corruption, tax rates, and tax administration. We assume that the firm owner/manager's perception of the business environment affects the firm's propensity to apply (i.e., credit need) but does not affect the bank's loan approval decisions. The dummy variable *APPLY* (Eq. 4) equals one if a firm applies for bank credit and zero otherwise. Finally, this study investigates whether pre-pandemic financing constraints exacerbate gender gaps in the access to financial resources for women-led businesses. To this end, following Khan, Shah, and Rizwan (2021) and Islam and Meza (2023), using the pre-pandemic baseline *WBES* dataset, a binary variable, *Credit Constraint*, equals one in four instances: rejection of a firm's loan application, partial approval of the credit requested in the bank loan application, a firm declining the loan offer due to stringent lending conditions (i.e., tough collateral requirements or higher interest costs), or the firm did not apply because of the perceived rejection of loan applications (discouraged borrowers). The credit constraint variable equals zero if the application is approved in full or if the firm indicates "*sufficient internal funds*" as the main reason for no application for bank credit.

3.3.2 Gender and Finance Access: Mediating Role of Corporate Digital Transformation Channel

Next, we examine whether gender disparities in loan supply are mediated by the adoption of digital tools, services, products, and platforms. Following Allison *et al*. (2023), we adopted mediation analysis procedures involving three regression models. Equation (3), which is our baseline model, examines the relationship between female ownership/leadership (i.e., *FEM-LED*) and finance access (*Finance*), and Equation (5) examines the impact of gender on corporate digital transformation and serves as the focal mediator channel in our analysis. Finally, the mediator channel was added as an additional independent variable in Eq. (6), where access to bank credit was the dependent variable.

$$Prob(\text{DIGITAL\_TRANSF}_{jkct}) = \beta_i X_{jkct} + \phi FEM\_LED_{jkct} + D_{ct} + \varepsilon_{jkct} \tag{5}$$

$$Prob(Finance_{jkct}) = \beta_i X_{jkct} + \lambda FEM\_LED_{jkct} + \omega \text{DIGITAL\_TRANSF}_{jkct} + D_{ct} + \varepsilon_{jkct} \tag{6}$$

where $DIGITAL\_TRANSF$ is a dummy variable that indicates whether an enterprise began or increased online business activities, such as e-commerce or remote work, or the online delivery of goods, services, and carryout during the COVID-19 pandemic. The coefficients γ (Eq. 3) and λ (Eq. 6) signify the total and direct effects of *FEM-LED* on a firm's access to credit, respectively, whereas the product of ϕ and ω in Eq. (6) ($\phi \times \omega$) signify the mediation effect (i.e., the indirect effect of *FEM-LED* on a firm's access to credit through the corporate digitalization channel). Figure 1 shows the mediation channel of DT on the gender-finance relationship. Following Allison et al. (2023), the same set of firm and country-level variables, used in equation (3), were also included in equations (5) and (6). Bootstrapping was used to estimate the statistical significance of the value of the product ($\phi \times \omega$) (Chang et al., 2013). The statistical significance of coefficients (λ and ω) in Eq. (6) implies partial mediation, whereas a statistically insignificant λ coefficient signifies complete mediation. Following Fernando et al. (2020), five thousand sub-samples were randomly selected with replacement from the original sample. Since observations are chosen by replacement, each original observation may or may not appear multiple times in the sub-sample. The total number of observations of the original sample was carried over to the subsample. Coefficients γ, ϕ, λ, and ω are saved after running the equation system designated by regression equations (3), (5), and (6) on the subsample. The statistic "($\phi \times \omega$)" for each iteration is calculated once this technique has been performed five thousand times. We created upper and lower 95% confidence level limits for the ($\phi \times \omega$) values using these five thousand observations.
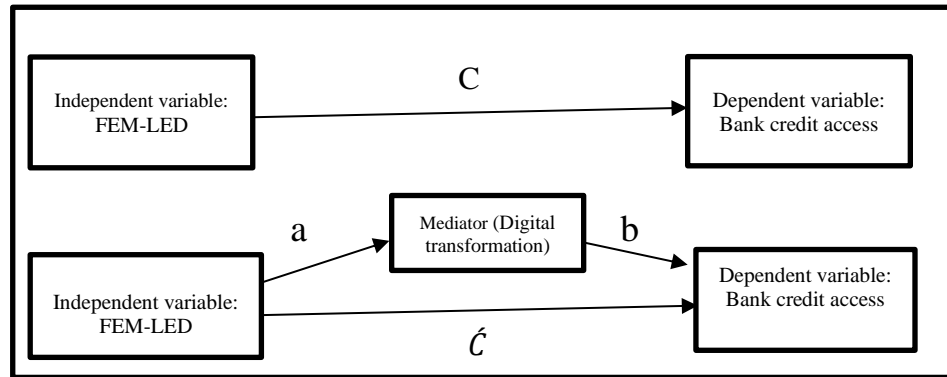

Figure 1: Mediation Analysis of Digital Transformation on Women-led Firm's Credit Access

4. Data Analysis and Empirical Results

4.1 Descriptive Statistics

Table 1 presents the composition of the sample by region and the share of women-owned (female ownership of 50 percent or more) and women-led (female top managers) businesses. Nearly three-fourths of the firms are from Europe and Central Asia, with a significant portion from the Middle East and North Africa (MENA) and sub-Saharan African countries. The overall share of women-owned businesses is 19.27 percent, with 17.6 percent of the sample being women-led establishments. Panel B of Table 1 shows that women-led establishments are smaller, younger, have a lower propensity to export, a lower share of foreign ownership, and fewer experienced top managers than their male-led counterparts. Sectoral heterogeneity shows that these measures of financial stress by gender appear to be more pronounced in the retail sector than in the other sectors (82 percent versus 68 percent).

Table 2 (*FEMALE-OWNED*) shows that the COVID-19 pandemic significantly affected the financial access and fragility of female-owned businesses. On average, 73.8 percent of female-owned businesses experienced liquidity shortfalls and overdue obligations, approximately four percentage points higher than that of male-owned businesses. Women-owned firms have a 4.3 percentage points higher financing need. However, given the higher demand for finance by women-owned businesses, there are statistically significantly more discouraged borrowers among women-owned firms than among men-owned enterprises (45.8 percent versus 39.4 percent). They also have less access to bank credit, with nearly one-fifth experiencing credit rationing. Furthermore, female-led firms experience greater financial distress, lower access to bank credit, and higher loan rejection rates when they have female top managers (Panel B, Table 2). We further test these preliminary findings using the econometric specifications discussed in the Methodology section.

4.2 Empirical Results

We first model the gender disparities in financing needs, loan application behavior, and credit self-rationing using the gender of the business owner and top manager as an independent variable. Table 3 presents the results of the probit model with selection by employing equations (1) and (2). The statistically significant value of the chi-square test confirms the existence of a selection bias and the validity of our econometric specification. Furthermore, the statistically significant correlation coefficient (rho) confirms the need to account for sample-selection effects. This negative correlation coefficient indicates that some firms prefer not to apply for bank credit out of fear of rejection by banks, and thus self-select from the formal credit market (Pigini et al., 2016). The positive coefficient estimates of *FEM-LED* in Column 1 shows that female entrepreneurs tend to have a higher demand for finance than their male counterparts. The marginal coefficients show that female-led firms are nine percentage points more likely to have a higher demand for external financing. This higher demand for bank credit may be partially influenced by a greater need for liquidity, as shown by the univariate test statistics in Table 2.

Approximately three-fourths of the women-led businesses experienced liquidity and cash flow shortfalls, which was 3.4 percentage points higher than that of their male counterparts. With many businesses, particularly women-led ones, experiencing decreased revenue, they may require financing to cover their operating costs, pay employees, and invest in new projects or technologies that can help them adapt to the changing economic landscape shaped by the economic uncertainty induced by the COVID-19 pandemic. However, consistent with prior studies (e.g., Carter & Shaw, 2006; Cowling et al., 2012), the negative coefficient of *FEM-LED* in Column 3 and the marginal coefficients show that female entrepreneurs have a 15% lower probability of applying for credit than male-led businesses, despite higher external financing needs. This result is in line with that of Cowling, Marlow, and Liu (2020) who find that female-led SMEs had a lower application rate for bank credit during the 2008 Global Financial Crisis (GFC). They attribute the lower credit request by female businesses to the "feminized risk aversion," which may constrain female entrepreneurs from applying for bank credit during periods of economic distress. This suggests that risk-aversion theories may explain their lower willingness to borrow compared with males, confirming H2 and H3. This shows that theories based on risk aversion may explain why female entrepreneurs seem to be less willing to borrow than male entrepreneurs. Gender disparities in risk tolerance in the domain of entrepreneurship have been found for both latent (i.e., potential) and active entrepreneurs regarding the most popular source of financing for the small business sector, bank lending (Verheul et al. 2012). As a result, the demand for bank credit is influenced by risk aversion, with female business owners showing higher reluctance to take on debt reflected in their lower demand for bank credit (Aguilera-Alfred, Baydas, & Meyer, 1994). As a result, the demand for the finance landscape portrayed by the available information points to a scenario in which various factors coalesce to channel women toward dependency on informal sources of financing (Hastings et al. 2013), while those seeking external financing from credit markets may be more cautious in their approach due to feminine risk aversion (Huang & Kisgen, 2013).

To explore the possibility that the apparently higher loan demand but the apparently lower application rates are confounded by women entrepreneurs being more likely to behave as discouraged borrowers, this study investigates gender bias in borrower discouragement, particularly among female entrepreneurs, and whether this may contribute to their lower loan application behavior. Following Gama et al. (2017), we identify bank-discouraged firms using the binary variable *DISC_BANK*, which indicates whether a firm did not apply because of high financing costs (direct costs include higher interest rates or tough collateral requirements, whereas indirect costs include cumbersome loan applications and bank paperwork) or fear of rejection. We test the probability of borrower discouragement, given that an establishment has shown demand for external finance in the probit model with selection, using the same exclusion restriction in credit demand selection equations (1) and (2). Column 5 of Table 3 shows that female entrepreneurs have a higher incidence of

borrower discouragement, suggesting that this credit self-rationing behavior may partially drive their lower loan application rates compared to their male counterparts. Cowling et al. (2022) pointed out that the severe liquidity constraints induced by the COVID-19 crisis led to a surge in loan demand and application rates, particularly influenced by working capital requirements. This also forced previously discouraged borrowers from applying for bank credit. However, the COVID-19 pandemic has significantly reduced business investments owing to postponement and pessimistic future expectations, resulting in a decrease in long-term credit demand (Buchheim et al., 2022). Our results partially support the findings of Liu et al. (2021), who document that Chinese SMEs' credit demand has decreased significantly, particularly in enterprises without prior bank relationships.

Table 1: Descriptive Statistics: Share of Women-led Businesses by Region

Region	N	Female-Owned	N	Firms with female top manager	N	FEM-LED: Women-owned firms with female top manager
Sub-Sahara Africa (AFR)	3,098	19.6%	6146	12.1%	6146	5.7%
East Asia & Pacific (EAP)	716	35.8%	720	42.2%	720	36.9%
Europe & Central Asia (ECA)	38,412	21.2%	39392	20.0%	39428	15.9%
Latin America and Caribbean (LAC)	398	20.1%	3746	21.4%	3746	1.2%
Middle East and North Africa (MENA)	7,697	8.0%	7953	6.4%	8005	4.5%
All countries		0.1927				0.1767

Panel B: Firm Characteristics by Gender								
		Age (years)	Small firm (5--19 employees)	Medium firm (200—99 employees)	Large firm (100+ employees)	Foreign ownership (10% or more)	exporter	Top Manager Experience (years)
Women-owned firms	Yes	19.24	0.603	0.291	0.107	0.036	0.155	19 years
	no	21.95	0.443	0.338	0.22	0.107	0.237	21.20 years
Difference		-0.71***	0.160***	-0.047***	-0.113***	-0.071***	-0.083***	-2.23***

Table 2: Mean Differences in Demand for and Supply of Finance, Bank Discouragement, and Credit Constraints by Gender of Firm Ownership and Leadership

		Credit demand	Apply for credit	Application Rejected	Bank discouraged	Bank financing	Equity financing	Overdue in financial obligations to banks	Liquidity decreased
Panel A: Women-owned business (female ownership 51% or more)									
FEMALE-OWNED	1	0.425	0.250	0.288	0.458	0.256	0.479	0.196	0.738
	0	0.382	0.267	0.188	0.400	0.309	0.542	0.162	0.696
Mean Difference		0.043***	-0.017**	0.100***	0.058***	-0.053***	-0.064***	0.034***	0.042***
Panel B: Female-ownership 51% or more, and top manager is female.									
FEM-LED (0, 1)	1	0.389	0.226	0.261	0.482	0.231	0.521	0.167	
	0	0.404	0.268	0.187	0.417	0.302	0.517	0.184	
Mean Difference		-0.016*	-0.042***	0.074***	0.066***	-0.071***	0.004	-0.017***	

Table 3: Demand for Finance and Bank Discouragement for Women Entrepreneurs

The probit model with selection (standard errors in parentheses) for Eq. (1) – (4). *FEM-LED* [0, 1] equals one for firms with a female CEO and at least one woman among the firm owners. *EXPORTER* [0, 1] equals one if an establishment has at least 10 percent of its sales as exports. *FOREIGN* [0, 1] equals one if foreign ownership in the establishment is 10 percent or more. *ONLINE_BUSINESS* [0, 1] equals one if an establishment started or increased its e-commerce activities. *WC finance* is the pre-pandemic share of working capital financed through internal funding. *Sale Change* is the monthly percentage change in sales compared with the previous year. *Demand Decrease* [0, 1] equals one if the demand for the establishment's products and services decreased compared to the previous year. The Larg firm dummy [0, 1] equals one if an establishment has 100 or more employees and zero if it has fewer than 100 employees. The *Small firm dummy* [0, 1] equals one if an establishment has fewer than 19 employees and zero otherwise. *LIQUIDTY* [0, 1] equals one if an establishment reported that liquidity and cashflow availability decreased during the COVID-19 pandemic. Govt Asst [0, 1] equals one if an establishment received financial assistance from the government during the COVID-19 pandemic. *Audit account* [0, 1] equals one if the establishment's financial accounts are audited annually by independent auditors. The dependent variables for each regression are indicated at the top of each column. *** $p<0.01$, ** $p<0.05$, * $p<0.10$

	Demand for Bank Credit		Loan Application Behavior		Bank Discouragement	
	(1)	(2)	(3)	(4)	(5)	(6)
	Credit Need	*Liquidity Decreased*	*Applied*	*Credit Need*	*Bank Discourag-ement*	*Credit Need*
FEM-LED	0.140***	0.0428	-0.101**	0.0017	0.103**	-0.0060
	(0.0513)	(0.0452)	(0.0480)	(0.0328)	(0.0479)	(0.0324)
AGE	0.00216	-0.00141	0.000236	-0.0017**	-0.000218	-0.00178**
	(0.00151)	(0.00127)	(0.00128)	(0.000836)	(0.00128)	(0.000823)
Small firm dummy	-0.00786	0.0860**	-0.240***	0.0225	0.239***	0.0181
	(0.0421)	(0.0363)	(0.0387)	(0.0261)	(0.0386)	(0.0255)
Large firm dummy	0.0473	-0.122***	0.0956*	-0.0660**	-0.0986*	-0.0591*
	(0.0559)	(0.0446)	(0.0526)	(0.0330)	(0.0525)	(0.0322)
Foreign Ownership dummy	-0.126*	-0.130**	-0.152**	-0.260***	0.164***	-0.301***
	(0.0667)	(0.0542)	(0.0627)	(0.0402)	(0.0629)	(0.0393)
Exporter dummy	-0.00879	-0.111**	0.0644	-0.0117	-0.0653	-0.0178
	(0.0436)	(0.0388)	(0.0444)	(0.0286)	(0.0444)	(0.0283)
WC finance	-0.296***	0.0775	-0.163***	-0.190***	0.192***	-0.275***
	(0.0610)	(0.0522)	(0.0574)	(0.0387)	(0.0575)	(0.0365)
Gov Asst	0.449***	0.377***	0.339***	0.248***	-0.341***	0.250***

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	(0.0648)	(0.0570)	(0.0397)	(0.0254)	(0.0397)	(0.0252)
ONLINE_BUSINESS	0.0258	0.266***	0.125***	0.0491**	-0.125***	0.0588**
	(0.0381)	(0.0362)	(0.0359)	(0.0247)	(0.0358)	(0.0244)
Sale Change		-0.499***		-0.404***		-0.406***
		(0.0624)		(0.0455)		(0.0451)
Demand Decreased		0.868***		0.396***		0.395***
		(0.0389)		(0.0291)		(0.0288)
Liquidity Decreased				0.354***		0.352***
				(0.0281)		(0.0278)
Indebtedness			0.411***	0.300***	-0.311***	0.3006***
			(0.0623)	(0.0417)	(0.0613)	(0.0164)
Audit account			-0.00129	-0.0359	-0.0139	-0.037
			(0.0385)	(0.0258)	(0.0375)	(0.0258)
Constant	1.717***	0.688	-0.288	0.00568	0.248	0.121
	(0.508)	(0.436)	(0.232)	(0.202)	(0.231)	(0.201)
Observations	7,875	7,875	15,808	15,808	16,124	16,124
Censored obs.	3385					
Uncensored obs.	4490					
Wald chi2(48)	473.35					
Prob. > Chi2	0.000					
Rho	-0.969***					
LR test of independence (rho=0): chi2(1)	211.94					
Prob > chi2 =	0.0000					
Industry & country dummies	Yes	Yes	Yes	Yes	Yes	Yes

Table 4: Gender and Access to External Financing: Bank Financing

Probit model with selection (standard errors are in parentheses). FEM-LED [0, 1] and other control variables are as defined in Table 3. Columns (1) and (3) present the results of the outcome equation (Eq. 3). Columns 2 (Eq. 3) and 4 (Eq. 2) present the results of the selection equations. *** p<0.01, ** p<0.05, * p<0.10

	(1)	(2)	(3)	(4)
	Bank Financing (2nd stage reg.)	Applied (1st stage reg.)	Bank Financing (2nd stage reg.)	Applied (1st stage reg.)
FEM-LED	-0.163**	-0.167***	0.126	-0.0227
	(0.0759)	(0.0613)	(0.105)	(0.0394)
FEM-LED x Credit constraint (WBES)			-0.384**	
			(0.179)	
AGE	-0.000177	-0.00160	-0.00258	-0.0014
	(0.00172)	(0.00147)	(0.00242)	(0.00099)
Small firm dummy	-0.206***	-0.174***	-0.373***	-0.188***
	(0.0563)	(0.0478)	(0.0698)	(0.0313)
Large firm dummy	0.153**	0.0155	0.428***	0.00245
	(0.0672)	(0.0564)	(0.110)	(0.0387)
Foreign Ownership dummy	-0.352***	-0.260***	-0.176	-0.223***
	(0.0851)	(0.0709)	(0.125)	(0.0491)
Exporter dummy	-0.000570	0.0173	-0.0234	0.0724**
	(0.0589)	(0.0510)	(0.0798)	(0.0338)
WC Finance	-0.498***	-0.406***	-0.0454	-0.246***
	(0.0777)	(0.0664)	(0.121)	(0.0462)
Govt Asst	0.296***	0.317***	0.195**	0.343***
	(0.0581)	(0.0489)	(0.0948)	(0.0305)
ONLINE_BUSINESS	0.101*	0.0639	0.0807	0.0514*
	(0.0525)	(0.0452)	(0.0669)	(0.0293)
Sale Change		-0.217***		-0.0425
		(0.0585)		(0.0532)
Demand Decreased		0.211***		0.165***
		(0.0403)		(0.0372)
Liquidity Decreased		5.871		0.231***
		(253.6)		(0.0372)
Constant	-0.907***	-6.495	-0.394	-1.115***
	(0.138)	(253.6)	(0.601)	(0.259)
Observations	7,391	7,391		

The probit model with selection in Table 4 (Column 1) shows a negative and statistically significant coefficient for *FEM-LED*, indicating that businesses with female ownership and female CEOs tend to have a lower likelihood of accessing bank credit during the pandemic. This finding supports the notion of gender disparity in the credit market (Treichel & Scott, 2006). This result is in line with Liu et al. (2021) who identify impaired access to bank credit as one of the main channels contributing to the negative effects of the pandemic on women-led businesses. However, this result contrasts with Hewa-Wellalage et al. (2022) who found that female-owned and female-led enterprises had a marginally higher probability (2 percent points) of obtaining bank credit during the COVID-19 pandemic than male-led enterprises. Our results also contrast with those of Cowling, Marlow, and Liu (2020), who show that female businesses had a lower demand for bank credit during the 2008 Global Financial Crisis, but that female businesses that applied for loans were more likely to receive bank lending than male businesses. They argue that feminized risk aversion might have played a role in female business loan application decisions, with the result that loan applications were more likely to be submitted by conservative, less risky but stronger female businesses during periods of economic uncertainty. This positively affects the likelihood of obtaining bank loans by female businesses, given that financial institutions tend to adopt self-protective and cautious behavior in their capital allocation during periods of economic downturns. However, Cowling et al. 's (2020) subtle, deeper analysis of the channels influencing financial institutions' loan approval decisions reveals that female businesses' loan applications suffer a disadvantage as financial institutions assign lower value to their collateral offered against loan security, indicating a gendered discrimination aspect in their credit supply to female businesses during the 2008 GFC.

This study also investigates whether pre-pandemic financial constraints worsened gender disparities in access to external financing among women-led businesses. The results of the interaction term between pre-pandemic credit constraint and *FEM-LED [FEM-LED × Credit_constraint (WBES)*] in Column (3) of Table 4 show that women-owned firms with pre-pandemic tight financial conditions were less likely to have access to bank financing. In fact, our results indicate that prior credit constraints aggravated gender disparities in credit access to women-led enterprises, confirming the findings of Artistie and Gallo (2023), Khan (2022), and Zhang and Sogn-Grundvåg (2022). Recent empirical studies show that firms facing pre-pandemic credit constraints are less resilient to economic shocks (Aristei & Gallo, 2023), suffered higher sales declines and show lower resilience in navigating the economic distress induced by the COVID-19 pandemic (Amin & Viganola, 2023). Balduzzi et al. (2020) find that firms with prior financial difficulties planned to cut future investments and employment more than are unconstrained firms. Analogously, Aristei and Gallo (2023) find that prior credit constrains significantly amplify liquidity and financing problems and amplify the pandemic's impact on firm performance and vulnerability. Our empirical results closely align with those of Khan (2022), who shows that prior credit constraints significantly exacerbated firms' financial vulnerability, credit

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risk, liquidity problems, and impaired access to bank credit during the COVID-19 pandemic. Our contribution to this strand of the literature is that pre-pandemic credit constraints intensify the negative impact of the pandemic on female-led firms' financial access and vulnerability.

Table 5: Instrumental Variable Probit Model (IV Probit)

This table presents the results of the instrumental variable (IV) probit models (standard errors in parentheses). Columns (1) and (2) presents the results of Eq. (1) and (2), respectively. Columns (3) and (4) present the results of Eq. (3) and (4), respectively. The dependent variable for each regression is reported at the top of each column. The Gender Development Index (GDI Dummy) is an instrument for FEM-LED. This binary variable equal 1 for countries with high equality in Human Development Index achievements between men and women.

*** p<0.01, ** p<0.05, * p<0.10

	(1)	(2)	(3)	(4)	(5)	(6)
	FEM-LED	Credit Need	FEM-LED	Bank Financing	FEM-LED	*DISC_BANK*
	First stage	2nd Stage	First stage	2nd Stage	First stage	2nd Stage
FEM-LED		2.062***		-2.35***		2.779***
		(0.8049)		(0.491)		(0.338)
AGE	-0.000125	-0.00124	-0.0006***	0.000114	-0.000412	0.00108
	(0.00018)	(0.000931)	(0.000212)	(0.00113)	(0.000278)	(0.00091)
GDI Dummy	0.071**		0.106***		0.0467	
	(0.0303)		(0.0392)		(0.0332)	
Control variables	Yes	Yes	Yes	Yes	Yes	Yes
Observations	18,017	18,017	14,728	14,728	8,121	8,121
Wald test of exogeneity Chi2 (1)		2.75*		5.28**		4.32**

Next, we exploit cross-country heterogeneity to examine whether the observed gender gaps in the credit market vary in severity depending on the most prevalent culture in each country. As in Mascia and Rossi (2017), we use the Global Gender Gap Index (GGGI) to account for cultural and institutional differences in gender-based disparities that characterize the countries in our sample. A biennial report generated by the World Economic Forum, the GGGI benchmarks national gender gaps in the economic, educational, health, and political domains. Using the 2020 Global Gender Gap rankings and the scores of the countries included in our sample, we split them into three clusters based on their relative rankings among the 153 countries covered by the index. Cluster 1, 2, and 3 consisted of countries with rankings from 1 to 50 (lowest magnitude of gender disparities), 51 to 83, and 84 to 153 (highest level of gender-based discrimination), respectively. The empirical results of the instrumental variable probit model (gender development index as an instrument for *FEM-LED*) in Eq. (1) – (4) for credit demand, bank

credit, and borrower discouragement, respectively, are presented in Table 5. Again, the coefficient estimates for *FEM-LED*, as reported in Columns 1, 3, and 5, are in line with our previous findings that female-led businesses are more likely to have higher demand for bank credit but are more likely to be discouraged from applying and denied credit by banks and financial institutions during the COVID-19 crisis.

Next, we examined the temporal heterogeneity that characterizes the panel nature of our survey dataset, covering two years from the start of the COVID-19 pandemic in 2020 and the subsequent year 2021. The first three waves of the COV-FS survey dataset were used for the empirical analysis. In our temporal heterogeneity analysis, we run our regression specifications separately for 2020 and 2021. The empirical results obtained using the COV-FS survey data for 2020 and 2021 are not reported in the paper for brevity but are available upon request. According to the coefficient estimates, female-led businesses experienced same loan demand as male-led businesses in 2020. This result contrasts with the findings of Cowling et al. (2020) for the 2008 GFC. They document significant differences in loan demand between female-led and male-led businesses in the early stages of the aftermath of the 2008 GFC; women-led businesses had significantly lower application rates than male-led businesses. However, by 2021, female-led businesses ran out of their resources and had a greater need for external funding. This outcome is in line with that of Wu's (2022) finding that firms' financial conditions deteriorated as the pandemic evolved and its economic impacts materialized. Additionally, female-led businesses were less likely to request bank financing during the early stages of the pandemic in 2020. However, as the pandemic progressed, their behavior changed, and female-led businesses became more active in seeking bank funding and were more likely to request bank loans compared to their male-led counterparts. However, the gender disparity in debt financing persisted because female-led businesses were less likely to secure bank credit than their male-led competitors were in the early and later years of the pandemic. Finally, during the later stages of the pandemic, borrowers' discouraged loan application behavior by gender and gender disparities also vanished and female businesses became active in seeking external funding.

4.3 Robustness Checks

Several robustness checks were conducted to examine the validity of the empirical results. Women-led firms have been disproportionately affected by the pandemic, leading to many exiting the market and, thus, have not been covered by follow-up *COF-FS* surveys. Thus, our empirical analyses are based on high-quality female-led firms that have survived the pandemic, highlighting the potential understatement of gender differences in terms of financial access and fragility. To address this potential selection bias, as in Birhanu et al. (2022), we used the *COV_FS* question "Currently is this establishment open, temporarily closed, or permanently closed?" to estimate the likelihood of a firm exiting a market. This dummy variable, denoted by EXIT, equals one if the firm's response is "open" to the stated question and equals zero for "permanently closed" responses. Approximately 5.23 percent

of the firms were permanently closed (3,097 of 59,176 firms). Moreover, despite several efforts, the teams conducting the follow-up survey were unable to locate a sizable portion of businesses, leading to the assumption that they either left the market or were permanently closed. The follow-up survey dataset revealed that the answer to the aforementioned question was missing for such establishments, implying an exit rate of approximately 16.73 percent (9,902 of 59,176 firms).

We follow Birhanu et al. (2022) and use information from the baseline WBES survey to estimate the likelihood of a firm exiting the market. We have information on both surviving and potentially exited enterprises because the follow-up surveys employed the same sample of firms from each country for which the WBES surveys were conducted the year before the COVID-19 pandemic.

We construct a proxy for a firm's indebtedness from the baseline WBES dataset by taking the average of three dummy variables: overdraft facility use, line of credit or bank loan, and the owners' personal outstanding loans. Highly indebted enterprises are more susceptible to bankruptcy during the COVID-19 pandemic. Credit defaults and exodus occur because of rising costs, a decline in revenues, and cash flow shortfalls. The second variable, Sunk Cost, represents the value of the land and buildings owned by a firm as a proportion of the total value of the land and buildings that a firm utilizes. For businesses that own the assets they use, exiting is a less desirable alternative because doing so puts a lot of risk (having to sell tangible assets during a crisis) and little benefit (in terms of rent savings) on the table. However, businesses with a high level of debt and reliance on rented capital have a strong incentive to file for bankruptcy in order to avoid paying rent and accruing interest.

The probit model (dependent variable: EXIT) estimates a firm's likelihood of selection in a sample based on two key independent variables: indebtedness and sunk cost. As reported in Table 6, there are gender differences in selection into the sample, as evidenced by the negative coefficient estimates for *FEM-LED* and *FEMALE_OWNED*. The coefficient for indebtedness shows an inverse U-shaped association, suggesting that establishments are more likely to permanently close and exit the market at very high (low) levels of debt (low levels of debt may imply a firm's credit constraints). The relationship between loan indebtedness and a firm's likelihood of selection in the sample is positively moderated by higher sunk costs. The predicted probability of selection was estimated from this model and used to construct the inverse Mills ratio, which was included in the Heckman probit model as an explanatory variable (Birhanu et al., 2022; Parker, 2018) in Equations (1)– (4). The level of indebtedness was also included in the specifications since pre-pandemic debt levels may also affect a firm's creditworthiness during the pandemic-induced economic crisis. The results of second-stage regressions for the Heckman selection model (Table 7) show the presence of selection effects and the robustness of the results after accounting for sample selection effects.

Second, as in Wellalage and Locke (2017), we account for the possibility that the owner/top manager's gender is endogenous to the firm's credit constraint using the gender development index (GDI) as an instrumental variable for *FEM-LED*. We construct a binary variable (GDI dummy) equal to one if a country falls in group 1, which comprises countries with high equality in Human Development Index (HDI) achievement between women and men and takes a value of zero otherwise. This analysis was conducted using an instrumental variable binomial probit model, which fits models for binary dependent variables in which at least one of the covariates is endogenous. The first stage involves estimating the predicted values of the endogenous variable (*FEM-LED*), using an instrument (GDI dummy) along with the control variables, which are then substituted into Equation (3) (See Seema, Seyyed, & Shehzad (2021) for further details and analysis).

Finally, Propensity Score Matching (PSM) (Rosenbaum & Rubin, 1983) and Blinder–Oaxaca decomposition (BOD) (Blinder 1973; Oaxaca 1973) technique were used to analyze the impact of gender on financial access. PSM accounts for endogeneity problems caused by omitted variables and self-selection bias. Developed by Rosenbaum and Rubin (1983), PSM pairs each treated unit with one or more control units that are comparable in all observable factors except for treatment status. PSM entails stratifying the sample into treatment and control groups based on independent variables. Consequently, the impact of the independent variable can be estimated while accounting for potential confounders. PSM compares companies with female ownership and leadership to those with male ownership and leadership, assuming non-systematic variations in responses to treatment. The results (Table 8) show that the average treatment effect on treated (ATT) is negative for bank financing. Female entrepreneurs are 5.1%–7.8 percentage point less likely to have access to bank credit during the COVID-19 crisis and are 8.3% more likely to be discouraged from applying for bank credit.

Table 6: Probit Model to Predict Probability of Selection in the Sample

Results of the probit model (standard errors are in parentheses). The dependent variable in columns (1) and (2) is a dummy variable that equals one if an establishment is either confirmed to have closed permanently or is believed to have done so because the teams conducting the follow-up survey were unable to identify them despite numerous attempts to do so. In Columns (3) and (4), the dependent variable is a dummy variable that equals one if a firm was confirmed to be permanently closed and zero otherwise. Indebtedness, estimated using the pre-pandemic baseline WBES dataset, is the average of three dummy variables identifying whether a firm (a) used an overdraft facility, (b) had a line of credit or loan from a financial institution, or (c) the owner's personal outstanding loans were used to finance business operations and growth. *** $p<0.01$, ** $p<0.05$, * $p<0.10$

	(1)	(2)	(3)	(4)
	selection 1: Confirmed and assumed permanently closed		selection 2: Confirmed permanently closed	
FEM-LED	-0.0467**		-0.0547*	
	(0.0224)		(0.0320)	
FEMALE-OWNED		-0.0883***		-0.0917***
		(0.0233)		(0.0326)
Small firm	-0.0914***	-0.0857***	-0.223***	-0.216***
	(0.0181)	(0.0186)	(0.0261)	(0.0268)
Large firm	-0.0523**	-0.0584**	0.126***	0.110***
	(0.0223)	(0.0231)	(0.0358)	(0.0369)
Foreign Ownership dummy	-0.0601**	-0.0732**	0.0269	0.0126
	(0.0281)	(0.0290)	(0.0453)	(0.0465)
Exporter dummy	0.0546***	0.0403*	0.0732**	0.0658**
	(0.0211)	(0.0216)	(0.0324)	(0.0331)
Indebtedness	0.0999	0.0876	0.389***	0.437***
	(0.0797)	(0.0813)	(0.116)	(0.118)
indebtedness_squared	-0.288***	-0.293***	-0.618***	-0.676***
	(0.0859)	(0.0881)	(0.126)	(0.129)
Sunk Cost	0.0439*	0.0588***	0.0647**	0.0963***
	(0.0234)	(0.0222)	(0.0322)	(0.0309)
Indebtedness x Sunk Cost	0.242***	0.234***	0.369***	0.304***
	(0.0536)	(0.0519)	(0.0774)	(0.0749)
Constant	1.159***	1.165***	2.542***	2.529***
	(0.147)	(0.147)	(0.292)	(0.292)
Observations	41,502	40,308	41,177	39,990

Table 7: Heckman Sample Selection Models

This table presents the results of the second-stage Heckman selection model which also includes the inverse Mills ratio estimated from a probit model to predict the probability of selection by a firm in the sample. The dependent variable for each outcome equation is represented by row headings. Standard errors are shown in parentheses. ***, **, and * represent statistical significance at the 1%, 5%, and 10% level, respectively.

	(1)	(2)	(3)	(4)
	Demand for Finance	Apply for Bank Credit	Bank Financing	
FEM-LED	0.0960*	-0.0586	-0.127***	
	(0.0571)	(0.0527)	(0.0371)	
FEMALE-OWNED				-0.0669*
				(0.0370)
AGE	0.0021	0.000495	0.00146*	0.00199**
	(0.0016)	(0.00142)	(0.000868)	(0.000881)
Small firm dummy	-0.0494	-0.185***	-0.148***	-0.150***
	(0.0519)	(0.0482)	(0.0319)	(0.0320)
Large firm dummy	0.0142	0.170***	0.0390	0.0717*
	(0.0623)	(0.0587)	(0.0363)	(0.0369)
Foreign Ownership dummy		-0.137*	-0.148***	-0.139***
		(0.0768)	(0.0489)	(0.0491)
Exporter dummy	0.0296	0.0686	-0.00221	0.00358
	(0.0472)	(0.0488)	(0.0318)	(0.0318)
WC Finance	-0.260***	-0.183***	-0.347***	-0.349***
	(0.0663)	(0.0625)	(0.0408)	(0.0408)
Govt Asst	0.408***	0.351***	0.360***	0.364***
	(0.0692)	(0.0423)	(0.0276)	(0.0276)
Inverse Mills Ratio	1.315**	-1.361**	-0.782*	-0.949**
	(0.663)	(0.628)	(0.420)	(0.416)
Indebtedness		0.298***		0.473***
		(0.0670)		(0.0448)
Sole Prop.	0.0304	0.0438		
	(0.0593)	(0.0522)		
ONLINE_BUSINESS	0.0171	0.0617	0.255***	0.265***
	(0.0422)	(0.0408)	(0.0311)	(0.0312)
ONLINE_SALE			-0.252***	-0.289***
			(0.0867)	(0.0882)
CORP				-0.225***
				(0.0550)
Constant	0.256	0.276	-0.624***	-0.631***
	(0.323)	(0.332)	(0.193)	(0.194)
Observations	7,073	14,878	21,110	20,633

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The BOD technique is commonly used in gender studies. An "unexplained" part that cannot be accounted for by group differences in measurable characteristics is often referred to as a proxy for gender discrimination in economic studies (see Cowling, Marlow, & Liu (2020) for more explanation on the BOD techniques). Table 9 shows that male-led firms have a higher likelihood of accessing bank financing than women-led firms, with predicted likelihoods of 30.3% and 22.5%, respectively and a mean difference of 7.8%. Approximately half of this difference (3.49%) is attributed to the model predictors, suggesting that female entrepreneurs have a lower probability of obtaining bank credit than male-dominated enterprises. However, according to the unexplained portion of the model, male-led enterprises have 4.3% higher probability of obtaining bank credit, suggesting that female entrepreneurs' lower access to bank credit is also influenced by factors unrelated to personal and firm-specific characteristics. Furthermore, gender differences in borrower discouragement are consistent with our earlier results.

Table 8: Robustness Tests: Propensity Score Matching

Dependent Variable	# of Treated	# of Untreated	ATT	t-stat
Credit Demand				
Nearest neighbor matching	2,503	15,514	-0.004	-0.24
			(0.0153)	
Kernel matching procedure	2,503	15,514	-0.003	-0.26
			(0.0106)	
Radius matching procedure	2,503	15,514	0.005	0.54
			(0.0096)	
Bank Financing				
Nearest neighbor matching	2,227	12,501	-0.051***	-3.51
			(0.0146)	
Kernel matching procedure	2,227	12,501	-0.049***	-4.85
			(0.0101)	
Radius matching procedure	2,227	12,501	-0.078***	-8.82
			(0.0088)	
Bank Discouragement				
Nearest neighbor matching	1,111	6,979	0.022	0.96
			(0.0233)	
Kernel matching procedure	1,111	6,979	0.039**	2.35
			(0.0166)	
Radius matching procedure	1,111	6,979	0.083***	5.52
			(0.0150)	

Note: ATT is the average treatment effect on the treated. The standard errors are shown in parentheses. *, **, and *** represent statistical significance at the 1%, 5%, and 10% level of significance, respectively.

Table 9: Robustness Test: Blinder-Oaxaca decomposition

	Credit Demand	Bank Financing	Equity Financing	Bank Discouragement
Overall effect				
Male-led Enterprises	0.369***	0.3026***	0 .554***	0.399***
	(0.00387)	(0.0041)	(0 .00418)	(0.00584)
Female-led Enterprises	0.374***	0.2245***	0.532***	0.482***
	(0.00967)	(0.00884)	(0 .00996)	(0.01499)
Difference: Male - Female	-0.005	0.0782***	0.022**	-0.0834***
Endowment effect	-0.009*	0.0349***	0.0252***	-0.0469***
	(0.0050)	(0.00470)	(0.0068)	(0.00719)
Discrimination effect	0.004	0.04327***	-0.0029	-0.03649**
	(0.00945)	(0.00941)	(0.00888)	(0.01548)
Observations	18,017	14,728	16,634	8,121

Note: Robust standard errors are in parentheses. *p < .10; **p < .05; ***p < .01

4.4 Mediation Analysis: Role of Digital Transformation on the Relationship Between Gender and Credit Access

Table 10 reports mediation analysis using regression specifications in Equations (5) and (6). The coefficient estimates of *FEM-LED* [Column 1] is economically and statistically significantly positive, suggesting that women-led businesses are more likely to adopt e-commerce and digital transformation of their business models, consistent with that of Torres et al. (2021), who documented that women-led businesses tend to increase the utilization of digital platforms in response to the COVID-19 pandemic. In contrast, Cai, Fan, and Du (20217) show that women have lower inclination toward use of newer information technologies. Analogously, Lashitew (2023) found that digital technology usage intensity was not associated with top manager gender during the COVID-19 crisis. Lashitew (2023) further argues that top managers' gender influences the way they respond to crisis situations in terms of risk-taking attitudes, thus making female-dominated businesses less likely to adopt e-commerce and remote work technologies because of feminized risk aversion. Our results tend to differ in this respect and agree with findings of Njiwa et al (2023) women-dominated businesses benefited from technology adoption by reducing the negative influence of female-dominance in ownership and management on business resilience during economic crisis. We find that female-led businesses tend to

adopt new technologies in the context of crisis situations. Furthermore, when *FEM-LED* and DT are included in Equation (6) in the context of the mediation analysis, the negative coefficient for the former, which decreased from -0.38 to -0.40, and the positive coefficient for DT are highly significant (Column 3), suggesting that female-led firms that adopted digital technologies had better access to bank credit. This result supports H5 and is consistent with the mediating effect of digital transformation on the relationship between gender and credit access, consistent with findings of Allison et al. (2023) who documented a significant moderation role of technology usage on the relationship between female top manager's gender and corporate financial performance using a cross-country sample of 130 developing and emerging economies.

The effects of mediation were formally tested using a bootstrapping procedure. The average value of the statistic ($\gamma \times \omega$) is 0.002 with lower and upper limits of confidence intervals at 95 confidence levels corresponds to 0.000474 and 0.003581, suggesting that the upper and lower limits do not straddle zero. This finding confirmed the statistical significance of the mediating effect. These results indicate partial mediation, because the direct effect of *FEM-LED* in Eq. (6) is also statistically significant, indicating the partial mediation of DT adoption by female-led firms in the relationship between gender and access to bank financing. This result is consistent with Bu et al. (2024), who document a significant alleviating effect of digitalization on SMEs' financing constraints by reducing their financing costs and leverage levels. Analogously, Xia, Qiao, and Xie (2022) note that corporate digitalization helps business build resilience to the COVID-19 pandemic by facilitating access to external financing and reducing financing cost. This result is also generally in line with Li et al. (2023), who identify DT's financial easing role as a potential channel for the positive impact of DT on labor share. Chen and Yuan (2021) argue that digitally transformed businesses tended to receive favorable financing treatment from financial institutions, effectively addressing financing constraints. Njiwa et al. (2023) show that firms' adoption of technology before and during COVID-19 moderated the negative relationship between female domination in ownership and leadership and economic resilience.

In summary, the mediation analysis shows that narrowing the gender gap in a firm's adoption of digital transformation improves the prospects of access to bank financing in female-led enterprises during the COVID-19 crisis. The COVID-19 pandemic has shown that women businesses have suffered deeper financial distress, and their financial inclusion has intensified the need for more efficient policy interventions to support women's entrepreneurship (Schuttenbelt, 2020; IFC, 2020).

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Table 10: Mediation Analysis of Digital Transformation on Finance-gender Link

This table reports the results of Eq. (3) (Column 2), Eq. (5) (Column 1), and Eq. (6) (Column 3), testing whether the gender-finance access link is mediated by women-led firms' adoption of digital technologies during the COVID-19 pandemic. *** p<0.01, ** p<0.05, * p<0.10

	(1)	**(2)**	**(3)**
	Mediator (Digital Transformation)	**Bank Financing**	**Bank Financing + Mediator**
FEM-LED	0.036**	-0.038**	-0.040**
	(0.01617)	(0.01800)	(0.01786)
Digital transformation			0.058***
			(0.01058)
AGE	-0.0006	0.0009*	0.001*
	(0.00051)	(0.00047)	(0.00048)
Small firm dummy	-0.034*	-0.115***	-0.113***
	(0.01873)	(0.02083)	(0.02037)
Medium firm dummy	-0.007	-0.049**	-0.049**
	(0.01536)	(0.02131)	(0.02112)
Foreign Ownership dummy	-0.006	-0.024	-0.024
	(0.01646)	(0.01645)	(0.01642)
Exporter dummy	-0.060***	-0.034**	-0.030*
	(0.01956)	(0.01617)	(0.01592)
WC Finance	-0.002	-0.118***	-0.119***
	(0.02090)	(0.03101)	(0.03071)
Govt Asst	0.070***	0.090***	0.086***
	(0.01486)	(0.01463)	(0.01408)
Own website	0.064***	0.031***	0.028**
	(0.01339)	(0.01107)	(0.01077)
CORP	-0.028	-0.071***	-0.070***
	(0.02450)	(0.02117)	(0.02116)
Foreign Technology	0.010	-0.013	-0.014
	(0.01601)	(0.01594)	(0.01605)
Employee Training	0.014	-0.004	-0.005
	(0.01462)	(0.0132)	(0.01331)
Demand decreased	-0.058***	-0.091***	-0.188***

		(0.02345)	(0.02342)
Constant	0.04525	0.377***	0.375***
	(0.02875)	(0.04438)	(0.04404)
Country and industry dummies	yes	yes	Yes
Observations	13,644	13,644	13,644
R-squared	0.1158	0.1377	0.1410
Median Analysis			
		95% Lower CI	95% Upper CI
Total effect_c: ϕ	-0.038**		
Direct effect c': δ	-0.040**		
Indirect effect_aXb: $\gamma \times \omega$	0.002**	0.000474	0.003581

5. Conclusion and Future Research

This study explores the impact of female ownership and the gender of a top manager on the firms' financial vulnerability and credit access during the COVID-19 pandemic using firm-level data from 39 developing and emerging economies. We provide robust evidence that women-led and women-owned businesses face a greater likelihood of experiencing higher borrower discouragement behavior; female-led businesses are less likely to apply for bank credit despite exhibiting higher credit need. Additionally, our results also agree with previous studies that women-led businesses have limited access to bank credit, whether in times of crisis or non-crisis periods, and that their credit application approval rates are also significantly lower than those of men-led enterprises. This finding contradicts previous studies that find little evidence of gender-based bias in the credit market but aligns with most recent studies supporting gender discrimination in the credit market during financial distress, such as the 2008 GFC and the COVID-19 pandemic. In summary, women-led businesses suffered deeper financial distress and limited access to bank credit to manage their short-term liquidity shortfalls, as well as medium-term financing and investment needs. We also assess the role of digital transformation in bridging gender-finance disparities in the credit market. We show that female-led businesses that have adopted e-commerce and remote work technologies have better access to bank credit than other businesses. These findings remain robust after accounting for alternative econometric specifications, endogeneity, and sample selection issues. Drawing on the longitudinal nature of our dataset, we find significant disparities in the impact on female-led firms across regions and over time during the COVID-19 pandemic (Rounds 1 to 3). Given the economic, institutional, and cultural differences across developing and emerging countries in our sample, the global context provides an analysis of the "contextual" nature of the female leadership-finance access relationship.

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An important factor in the gender gap in access to external financing is the limited access to and use of digital technologies in female-led firms. However, the gender of top managers was not associated with the utilization intensity of these online technologies (Lashitew, 2023). On the other hand, Njiwa et al. (2023) demonstrated that pre-pandemic and during-pandemic technology usage enhanced female-led businesses' resilience to pandemic-induced economic shocks. Our results are in line with those of Torres et al. (2021), who found that women-led businesses tend to adopt digital technologies in response to the COVID-19 pandemic. This study empirically demonstrates that female-led enterprises' use of digital technology and the digital transformation of their business models can mitigate the negative effects of female ownership and leadership on financial friction and access to bank credit. Overall, these findings imply that if there are gender gaps in access to finance, they are partially closed by women-led businesses that digitalize their operations. As a result, these businesses were better able to manage the COVID-19 challenges and were better positioned to have better access to finance. Our results are generally in line with those of Njiwa et al. (2023), who showed that gender gaps in firms' resilience during the COVID-19 crisis were mitigated by female-led firms' adoption of digital technologies in the pre-pandemic period, which allowed them to be better equipped to manage the negative consequences of the pandemic and remained afloat during the crisis. However, this study partially contradicts Njiwa et al.'s findings, which suggest that COVID-19 increased the negative relationship between gender and firm resilience owing to costly digital technology investments. The lack of financial resources may have pushed female-led firms to reduce their digital technology investment, causing liquidity pressure and affecting business operations. We argue that digitally transformed female-led businesses have a better chance of obtaining external financial resources, because digital transformation increased these firms' resilience to the negative consequences of the COVID-19 pandemic and better placed them to access credit markets for external financing. Women generally have lower attitudes toward and preferences for technology adoption and utilization (Genz & Schnabel, 2023). Cai et al. (2017) revealed that the so-called "technological gender gap" persists despite recent developments in technology and its ubiquitous infiltration at both societal and organizational levels. These gender-based disparities in technology diffusion may put women-led businesses in a disadvantageous position in fighting economic challenges.

5.1 Managerial Implications

This study offers several managerial and policy implications. First, female-owned, and female-run businesses suffered greater financial distress and were more vulnerable to the economic consequences of the COVID-19 pandemic. Impaired access to external financing for women entrepreneurs has been one of the main constraints inhibiting their entrepreneurial growth. The empirical analysis further revealed that gender disparities in the credit market persisted during the COVID-19 pandemic as it evolved, and its effects

unfolded over an extended period. Based on the theories of discriminatory "gendered ascriptions", we argue that female-led businesses experienced gender disparities in the credit market in times of economic and financial distress and their financial inclusion has intensified the need for more efficient policy interventions to support women's entrepreneurship.

Second, female-led businesses have shown the capacity to adapt to digital technology usage (Njiwa et al., 2023; Allison et al., 2023); however, they often face constrained access to financial resources. This can hinder their ability to access the financial services required for survival and growth. Given the findings of a consistent gender gap in credit access during the COVID-19 pandemic, our empirical results suggest that these were partially filled by female-owned and female-run businesses that digitalized their production and management operations and used digital platforms for e-commerce activities. Thus, the managerial implications of our findings is that female-led businesses that leveraged their resources in adopting digital technologies were better positioned to obtain better access to financial resources to manage liquidity shortfalls and improve their financial resilience. Recent studies have shown that female-led enterprises that adopted digital technologies both in the pre-pandemic and during-pandemic times demonstrated higher resilience to economic shocks (Njiwa et al., 2023; Santos, Liguori and Garvey, 2023). Female-led businesses face constraints and challenges in adopting digital technologies; however, they exhibited similar technology utilization intensity during the COVID-19 pandemic (Lashitew, 2023; Tønnessen, Dhir, and Flåten, 2021). This suggests that female top executives can perform equally well compared to their male counterparts in the utilization of technologies given the financial and other resources required to develope technological infrastructure in their enterprises. According to our empirical analysis, we suggest that female-led businesses should develop dynamic competencies in digital technologies and related resources to better cope with existing and future challenges and crises and position their businesses to have better access to external financial resources. Thus, technology adoption can make female businesses financially more resilient and better prepare them to face future challenges and crises.

5.2 Limitations and Future Research

Exploring gender disparities in the credit market in the context of extreme financial distress such as the COVID-19 pandemic and the role of digital transformation in closing gender disparities in the credit market, this study has a few limitations that leave room for future research. First, gender bias tends to manifest more during the upside phase of the economy (Galli et al., 2020). Combining this (Galli et al., 2020) finding with our analyses, which were derived by conducting our research in times of extreme economic and financial distress, such as the COVID-19 pandemic, implies that gender differences in bank borrowing behavior follow cyclical trends. We reserve further investigation of this in the future, as it requires a longitudinal approach. Future studies are warranted to examine whether patterns of gender discrimination still exist when the pandemic's economic

consequences have diminished, and more comprehensive, rich, and granular datasets covering longer periods have become available for analysis. While bank funding constitutes one of the main sources of small business financing, we acknowledge and encourage the exploration of how discrimination, gendered ascriptions, and female business funding can influence female-led and female-owned businesses' access to alternative sources of external financing during periods of high economic uncertainty such as the COVID-19 pandemic.

Overall, our study demonstrates the pervasive effects of the pandemic on gender disparities in the loan market. Future empirical studies should examine how long the damaging consequences of the credit crunch persist among SMEs, even when firms have recovered in the post-pandemic period. It may also be worthwhile to conduct replication studies to determine whether gender trends in bank funding revert to their previous state after the economy achieves sustained and reliable growth.

Research Funding

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