Women's Income and E-commerce Adoption Amid COVID-19: Evidence from Peru´

Hector Botello*

PhD student, Washington State University. MA in Economics, Universidad Nacional de Colombia. BA in Economics, Universidad Industrial de Santander, Bucaramanga, Colombia. Researcher, Research Group on Regional Development and Land Use Planning. E-mail: hector.botello@wsu.edu. Orcid: http://orcid.org/0000-0002-7795-2590School of Economics, Washington State University, Pullman, USA;

Women’s Income and E-commerce Adoption Amid COVID-19: Evidence from Peru

This study focuses on Peru and the impact of e-commerce adoption on women's income levels during the COVID-19 pandemic. The research uses longitudinal data from the Encuesta Nacional de Hogares (2018–2022) and a Difference-in-Differences-in-Differences (DDD) model to examine how digital platforms shaped income generation, entrepreneurial activities, and economic resilience among women. Results reveal that e-commerce adoption enhanced income stability, particularly for women entrepreneurs, by mitigating some of the economic disruptions caused by the pandemic. However, persistent structural barriers—including limited digital infrastructure, socio-cultural norms, and regional disparities—restricted broader benefits, particularly in rural areas. The triple interaction analysis demonstrates that women who adopted e-commerce during the pandemic experienced higher income resilience than men and non-adopters.

These findings underscore the transformative potential of e-commerce for gender equity but also highlight the need for targeted interventions to bridge digital divides. Recommendations include expanding digital literacy programs, improving internet access in underserved regions, and fostering inclusive financial systems to support women's economic participation. This study contributes to global discussions on digital inclusion, gender equality, and economic resilience, providing actionable insights for policymakers in developing countries seeking to promote equitable digital economies.

Keywords: E-commerce, COVID-19, gender disparity, digital inclusion, Peru, income resilience.

Introduction

The COVID-19 pandemic overturned the traditional economic model, fast track speeding countries towards digital markets as well as income earners worldwide

(Angelov & Waldenström, 2023). Perhaps more than any other factor, the pandemic revealed the possibility of e-commerce as a lifeline for many women entrepreneurs and workers who have turned to online avenues to maintain and even grow their revenue during economic lockdowns. Such a transition led to increased research focusing on the nexus between gender, online engagement, and economic resilience, receiving groundbreaking insights about the changing nature of women's economic participation through digital platforms (Torres et al., 2023; Bala, 2024).

The recent growth in academic literature underscores the importance of e-commerce in advancing economic resilience and autonomy for women, especially in developing regions where traditional work options may be limited or disrupted (Morell, 2022; Ojo, 2022). Pivotal studies have documented cases where women effectively utilized online marketplaces to overcome barriers in conventional employment and amplify their financial independence during the pandemic (Pejić-Bach, 2021; Odoch et al., 2024). As a result, this research area has attracted substantial scholarly interest, with high citation counts reflecting an acknowledgment of its relevance across fields such as gender studies, economic development, and digital entrepreneurship (Bhardwaj & Singh, 2020; Afshan et al., 2021).

There is several way ecommerce acts as way to empowerment women towards a better income. The capability approach focuses on the opportunities, resources, and choices associated with helping people achieve economic or social well-being (Sen 1999). By providing flexible work opportunities, enabling more comprehensive market access, and making income perspectives otherwise inaccessible available to them due to socio-cultural or geographical impediments — e-commerce can expand the capabilities

of women. This framework illustrates the transformative power of e-commerce in increasing women's autonomy, incomes, and economic participation.

Digital divide theory describes differences in digital technology access and use, frequently along income/education/gender lines (van Dijk, 2020). The framework divides the divide into three levels — access, digital skills and effective use. In addition, women in developing regions, and especially rural or marginalized areas tend to face barriers at each of the three levels which could prevent them from reaping the benefits associated with e-commerce. This approach situates the inequitable advantages of e-commerce within a structural framework of systemic inequalities.

Based on frameworks of gendered economic empowerment (Kabeer, 1999), this paper considers how e-commerce influences women's roles within households and communities. Economic empowerment through e-commerce involves income generation and shifts in power dynamics, decision-making, and societal perceptions of women as economic agents. However, entrenched social norms and structural barriers, such as limited access to financial capital and digital literacy, may moderate these benefits, perpetuating existing inequalities.

Despite this optimistic outlook, the path to digital economic participation for women is often obstructed by skill gaps, limited access to capital, and socio-cultural constraints, particularly among women from marginalized communities. Such disparities hinder many women from fully harnessing the opportunities of e-commerce, leading to calls for targeted interventions that can bridge these gaps and promote inclusive digital engagement (Graeber, Koch & Hiller, 2021; Masroor et al., 2020). Consequently, while e-commerce presents opportunities for income diversification and economic resilience, it also risks perpetuating or even exacerbating existing inequalities if left unaddressed (Zhang & Wang, 2020). Peru provides a compelling case to examine

these dynamics. As one of the countries hardest hit by the pandemic, Peru faced prolonged economic lockdowns and significant disruptions to traditional employment sectors. Despite these challenges, the rapid expansion of internet access and digital platforms created opportunities for e-commerce growth. However, significant barriers—such as rural-urban divides, gendered digital literacy gaps, and limited financial inclusion—persist, making it critical to investigate the nuanced impacts of e-commerce adoption on women's economic resilience. Understanding Peru's context contributes to global debates on fostering inclusive digital economies in developing regions.

This study contributes to the growing literature on e-commerce's gendered impacts by examining women's unique challenges in developing regions like Peru. While e-commerce presents significant opportunities, persistent barriers limit its potential to reduce gender disparities. This study employs a Difference-in-Differences-in-Differences (DDD) model to capture the intersectional impacts of e-commerce adoption, gender, and the post-COVID period on income dynamics. The DDD approach allows us to disentangle the compounded effects of these factors while addressing concerns about unobserved heterogeneity. By analyzing longitudinal data from 2018 to 2022, the research identifies how women in Peru engaged with e-commerce to enhance financial resilience and explores the persistent barriers limiting its transformative potential.

Our findings reveal that while e-commerce adoption positively correlates with income stability, its benefits are unevenly distributed. Women entrepreneurs experienced significant income gains post-COVID, but pre-existing barriers, such as limited access to digital tools and entrenched socio-cultural norms, dampened their

ability to capitalize on these opportunities fully. These insights highlight the importance of addressing structural barriers to ensure equitable digital inclusion and sustained economic empowerment for women.

This paper proceeds as follows. Section 2 reviews the existing literature on e-commerce and gender, examining how digital platforms impact women's economic participation, particularly in times of crisis. Section 3 outlines the dataset and methodological approach, including selecting variables that capture e-commerce adoption and income dynamics over time. Section 4 presents the empirical results, highlighting the role of e-commerce in income stability and resilience for women entrepreneurs during the pandemic. Section 5 discusses these findings within the context of existing research, considering the implications for gender equality and digital inclusion. Finally, Section 6 offers conclusions and policy recommendations to foster inclusive digital economies that support women's long-term economic empowerment.

Literature Review

More global merchants adopting e-commerce due to the COVID-19 pandemic opened new doors for women's economic empowerment (Bahri, 2020), especially in areas where traditional roles have sustained gender inequality over the decades. Research in Bangladesh shows that e-commerce provides a convenient and stable lifestyle for women to combine home chores with working from home, reinforcing their financial resilience (Masum et al., 2022; Mohammad et al., 2021; Uddin & Barua, 2024). In parallel, studies conducted in China find that participation in e-commerce improves female self-esteem and social standing, yielding non-pecuniary advantages and denying a negative impact on the overall economic agency among women (Wang et al., 2024; Li & Zhou, 2023; Liu & Ma, 2016). These empirical findings are supported in

theory. In conjunction, the Technology Acceptance Model (Davis, 1989), Theory of Planned Behavior (Ajzen, 1985), and Innovation Diffusion Theory (Rogers, 2010) propose that e-commerce can play a significant role in providing women opportunities for financial independence by enabling them to balance better performing business or household duty from distant locations. These frameworks highlight e-commerce's potential to reshape traditional gender roles, particularly in conservative societies where economic opportunities are often restricted (Haq et al., 2021; Venkatesh & Morris, 2000).

The pandemic's impact on e-commerce adoption and income stabilization varied across regions. In Mauritius, self-employed women who transitioned to online platforms sustained or improved their income despite widespread economic disruptions (Kasseeah, 2023). Micro and small enterprises selling online in Peru increased significantly from 8.1% before the pandemic as businesses adopted digital strategies to reach customers (Astarloa et al., 2021). The global e-commerce market demonstrated remarkable resilience, with a projected growth rate of 12.2% in 2022 (Wani & Mohamad Ali, 2022). This growth was consistent across regions, including developed and developing countries (Dumanska et al., 2021; UNCTAD, 2021).

However, this growth was different. In Indonesia, 85.83% of e-commerce business actors reported income declines due to supply chain disruptions (Suwandi et al., 2022). Similarly, in Medan City, over 53% of micro, small, and medium enterprises (MSMEs) saw a decline in asset value, with two-thirds experiencing reduced income (Sutejo et al., 2022). Assistance needs were prevalent among small enterprises, particularly in working capital, to stabilize income, affecting both e-commerce adopters and non-adopters (Lestari et al., 2021; Riadi et al., 2022).

Developing countries face significant structural challenges that impact e-commerce adoption and effectiveness. Poor internet connectivity, inadequate infrastructure, and security concerns create substantial barriers to entry (Nitika, 2023; Khan et al., 2016). Limited access to reliable internet services restricts market participation, while lack of trust in online platforms and limited digital literacy hinder adoption rates (Ngo, 2022; Kanyaru & Kyalo, 2015). In rural South Africa, women face additional barriers, such as inadequate internet access and digital literacy, which hinder their ability to participate in e-commerce effectively (Donga & Chimucheka, 2024). SocioeconomicSocioeconomic factors, including low literacy rates and limited access to banking facilities, further compound these challenges (Khan et al., 2016; Heng et al., 2024).

Despite these challenges, e-commerce has proven instrumental in stabilizing or enhancing income levels during the pandemic. In India, partnerships with e-commerce platforms have helped women entrepreneurs expand their market reach and increase profitability, underscoring e-commerce's role in economic resilience (Verma & Kumar, 2021; Akther 2023). Braun et al. (2023) corroborates these findings in Australia, where e-commerce adoption helped safeguard incomes in vulnerable sectors. The pandemic catalyzed digital transformation, pushing traditional businesses to move online to counteract declining shares of conventional trade and unstable markets (Zou & Cheshmehzangi, 2022; Galhotra & Dewan, 2020).

Digital financial inclusion has emerged as a crucial enabler of women's economic empowerment through e-commerce. During the pandemic, the necessity for non-contact financial services accelerated the adoption of mobile banking and digital payments (Alarifi & Husain, 2023; Fungáčová & Weill, 2015). In Saudi Arabia, digital financial inclusion has been linked to improved financial management and economic

participation for women, granting them greater decision-making power within their households (Mabrouk et al., 2023). Similarly, studies reveal that access to digital payments in rural China has increased women's household bargaining power and financial autonomy (Wang et al., 2024).

Self-help groups (SHGs) have proven particularly effective in advancing digital financial inclusion among women. In India, integrating open banking processes and mobile technologies has enhanced financial access, literacy, and decision-making power among SHG members (W & Hangarki, 2024; Sarawagi & Singh, 2024). Projects like E-Shakti have successfully digitized SHGs, increasing financial sustainability and accessibility and enabling women to engage in income-generating activities (Sarawagi & Singh, 2024; Belho & Konwar, 2024).

This implies that e-commerce could be an opportunity to empower women but needs to be improved to effectively do so in many developing countries due to underlying structural and cultural barriers. In most conservative societies like Bangladesh, women are incredibly restricted in using technology via traditional expectations and social norms (Masum et al., 2022; Rahman et al., 2023; Uddin & Barua, 2024). Low accessibility to the Internet with cultural restrictions remains one of the main barriers for women in digital markets (Masum et al., 2022; Najaf et al., 2021). Skepticism regarding online payments due to the risk of fraud and data breaches is also a significant impediment to e-commerce in developing countries (Ngo, 2022; Nitika, 2023; UNCTAD, 2022). Given the existing theories on financial inclusion, if the reduction in the gender gap in digital financial inclusion could occur, this may facilitate consumption regulation, mitigate her business potential as a new source of financial risks, especially among women in underserved areas (Suri & Jack, 2016; Demirgüç-Kunt et al., 2018; Elzahi Saaid Ali, 2022). Government initiatives and institutional

support play crucial roles in this process. In Indonesia, government measures and the role of the Indonesian Deposit Insurance Corporation have been significant in empowering women entrepreneurs through digital banking services (Alfarizi et al., 2023). In ECOWAS countries, national financial inclusion strategies aim to enhance access to financial services and promote gender equality (Akeju, 2024).

The future of women's participation in e-commerce depends on addressing these structural challenges through targeted interventions. Improving digital infrastructure, enhancing cybersecurity measures, and increasing financial inclusion are essential (Zhang et al., 2024). Additionally, fostering digital literacy and trust-building initiatives can help shift consumer behavior toward embracing e-commerce, ultimately contributing to economic development in these regions (Nghargbu & Jumare, 2024; Bejaković & Mrnjavac, 2020). The success of such interventions requires a comprehensive approach that addresses both technical barriers and underlying social norms that discourage women's economic independence (Hendriks, 2019; Popescu, 2022).

Methodology

Data

We draw data from the Encuesta Nacional de Hogares (ENAHO), an annual nationally representative household survey fielded in Peru by the Instituto Nacional de Estadística e Informática (INEI). The ENAHO is a longitudinal survey that collects information on individual and household socioeconomic characteristics, including income, employment status of each household member, education level, and access to

public services. The dataset comprises various modules, including those on employment, household composition, and economic activities that play an essential role in the analysis carried out in this paper. Interviewers surveyed urban and rural areas of all 24 departments of Peru and the Constitutional Province of Callao, including diverse geographic and socioeconomic contexts. In this study, we utilized administrative data between 2018 and 2022 while analyzing the evolution of leading indicators, especially pre- and during the COVID-19 pandemic. The ENAHO design is a multi-stage probabilistic sampling design, stratifying by geographic areas (coastal, highland, and jungle regions) and urban-rural. For this analysis, we utilize the ENAHO panel dataset, which comprises approximately 12,188 households revisited over multiple waves. This allows for a robust longitudinal examination of household dynamics.

The variables central to this study include:

- **Income of the primary activity**: Captured through absolute and standardized measures, ensuring comparability across years and geographic regions. It is measured in Sol Peruvian currency.

- **E-commerce Adoption**: Indicated by responses to questions regarding using the Internet for selling goods or services in virtual markets like Facebook, mercadolibre, OLX, web pages, etc.

- **Gender**: Derived from individual responses to demographic questions.

Survey weights provided by the ENAHO ensure that the dataset is representative of the national population. These weights are employed in all analyses to adjust for sampling design and ensure accurate inference.

Empirical Strategy

We use a difference-in-difference-in-differences (DDD) model to assess the role of e-commerce adoption in income during COVID–19 through gender comparison. Our DDD approach allows us to disentangle the impact of three dimensions of variation: time (pre- vs. post-COVID), treatment (e-commerce adopters vs. non-adopters), and subgroup (female vs male). The study period of 2018–2022 afforded a comparison between the pre-COVID (2018–2019) and post-COVID (2020–2022) eras. The *post* variable refers to the time dimension, which equals 1 for observations from the second half of 2020 and forward —and 0 otherwise. The last set of factors is e-commerce adoption; the variable *e-commerce* identifies those who answered that they had used the Internet to offer products or services for sale in this calendar year. This variable serves as the critical treatment indicator. Gender is introduced as the third dimension. The variable *female* takes a value of 1 for women and 0 for men, enabling an analysis of how the pandemic's impact on income differs by gender.

The primary equation is structured as follows:

$$y_{it} = \beta_0 + \beta_1 post_t + \beta_2 ecommerce_{it} + \beta_3 female_i + \beta_4 (post_t \times ecommerce_{it}) + \beta_5 (post_t \times female_i) + \beta_6 (ecommerce_{it} \times female_i) + \beta_7 (post_t \times ecommerce_{it} \times female_i) + \beta_8 y_{i,t-1} + X_{it} + \mu_i + \epsilon_{it}$$

Where:

- y_{it}: Outcome variable (income, analyzed in levels, standardized, and log-transformed).
- p$post_covid_t$: Binary indicator for the post-COVID period (1 for 2020 and later, 0 otherwise).
- $ecommerce_adoption_{it}$: Binary indicator for individuals using the Internet to sell products/services.
- $female$: Binary indicator for gender (1 for women, 0 for men).

- X_{it}t: Control variables, including age, education level, occupation type, and survey month fixed effects.
- μ_i: Individual fixed effects accounting for unobservable time-invariant heterogeneity.
- ϵ_{it}: Idiosyncratic error term.

The coefficients are β_0, representing the average income level for the baseline group (male non-adopters of e-commerce in the pre-COVID period), controlling for other variables. β_1 captures the average change in income for the baseline group after the onset of COVID-19. This coefficient reflects any general income changes caused by macroeconomic disruptions due to the pandemic, such as lockdowns or economic downturns, not specific to e-commerce adoption or gender. β_2 reflects the difference in income between adopters and non-adopters of e-commerce in the pre-COVID period. This isolates the pre-existing economic benefits (or disadvantages) associated with e-commerce adoption, independent of the pandemic or gender. β_3 estimates the baseline income difference between men and women among non-adopters of e-commerce in the pre-COVID period. This coefficient reflects existing gender income disparities before considering pandemic effects or e-commerce. β_4 measures the additional change in income for e-commerce adopters compared to non-adopters after the onset of COVID-19, holding gender constant. A positive coefficient indicates that e-commerce adoption helped mitigate pandemic-related income losses or provided additional income opportunities during this period. β_5 captures the differential impact of the COVID-19 period on women compared to men among non-adopters of e-commerce. A negative coefficient would suggest that women faced disproportionately more significant income losses or fewer gains due to the pandemic. β_6 Represents the difference in income between male and female e-commerce adopters in the pre-COVID period. This

coefficient highlights whether women faced structural barriers or unique benefits in utilizing e-commerce for income generation before the pandemic. β_7 captures the differential impact of e-commerce adoption on women's income relative to men's during the post-COVID period. A positive coefficient indicates that e-commerce adoption disproportionately benefited women during the pandemic, potentially narrowing gender income disparities. Conversely, a negative coefficient would suggest that women faced unique challenges in leveraging e-commerce during this time. This is the most exciting coefficient for our study.

We include the lagged income term to ensure that the persistence of income changes over time is appropriately accounted for. Therefore, β_8 reflects the effect of lagged income on current income, accounting for income persistence or autocorrelation over time.

The control variables were selected for individual and temporal factors influencing income, like age, education, and occupation type. We also adjust for seasonality in economic activities using the survey month.

To address potential biases in our model, we validate the robustness of the findings; two exercises were conducted:

1. **Alternative Timing of the Post-COVID Period**: The post-COVID indicator was redefined to start in 2021, allowing for the possibility of delayed economic effects of the pandemic. Results were compared to the primary specification.
2. **Placebo Test**: The analysis was restricted to pre-COVID years (2018–2019) to ensure that pre-existing trends did not drive observed effects. Significant results in the placebo test might indicate that spurious relationships, model specification issues, or unaccounted confounders could drive the main results.

Results

This section presents the empirical findings on the impact of e-commerce adoption on women's income during the COVID-19 pandemic. The analysis explores differences by gender, e-commerce adoption, and periods using DiD and DDD estimation frameworks.

The descriptive statistics in Table 1 provide a comprehensive overview of the dataset, disaggregated by gender and pre-/post-COVID periods. The mean income levels reveal significant gender disparities, with men consistently earning higher incomes than women across both periods. However, both groups experienced lower mean incomes in the post-COVID period, suggesting a widespread economic impact of the pandemic.

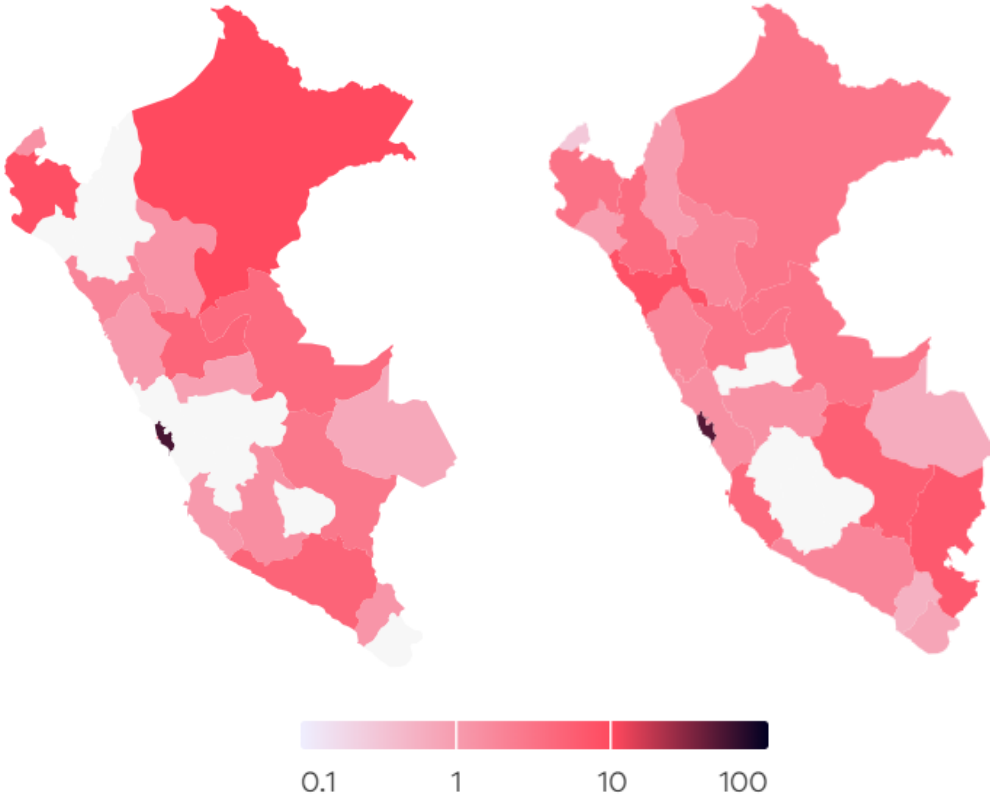
Table 1: Descriptive Statistics by Gender and COVID Period

Variable	Gender	Pre-covid		Post-covid	
		Mean (SD)	N	Mean (SD)	N
Income	Male	8241.13 (14716)	2,908	8214. (14819)	4,379
	Female	8640.93 (14707)	2,174	7846 (15189)	3,109
E-commerce	Male	0.0134 (0.11)	2,910	0.014 (0.119)	4,382
Adoption	Female	0.0188 (0.13)	2,177	0.0285 (0.16)	3,118
Age	Male	47.52 (15.59)	2,910	47.60(16.43)	4,382
	Female	47.59 (15.16)	2,177	47.77(15.95)	3,118
Education Level	Male	5.46 (2.26)	2,910	5.52 (2.24)	4,380
	Female	5.30 (2.67)	2,176	5.45 (2.69)	3,118
Years Worked	Male	14.79 (14.48)	2,910	14.32(15.36)	3,725
	Female	9.10 (11.35)	2,177	9.05 (11.97)	2,733

Figure 1 displays the geographic distribution of e-commerce adoption across Peru's departments between 2018 and 2022, highlighting the disparities in adoption rates. The maps show concentrated adoption in urban and coastal areas, particularly in Lima, which accounts for nearly half of all e-commerce adopters. The second map illustrates 2022 trends, indicating slight expansions in adoption to neighboring departments. However, the central and Amazonian regions consistently show lower adoption levels, suggesting that internet accessibility and digital literacy may influence adoption rates. These visuals underline the urban-rural and regional disparities critical for policy interventions aimed at equitable digital inclusion.

Figure 1. E-commerce adoption by region in Perú. Proportion of workers selling products online

2018 2022



E-commerce adoption rates are meager across all groups, with women showing a slightly higher mean adoption rate than men. This aligns with emerging narratives of women leveraging digital platforms as an alternative income source during economic disruptions. The variation in adoption rates, as captured by standard deviations, is minimal, indicating that most respondents have yet to engage in e-commerce.

In terms of demographic characteristics, women, on average, are slightly older than men, and their average educational attainment is marginally lower. These factors could influence income disparities, as older age and lower educational levels limit access to higher-paying opportunities.

The variable measuring years worked in the main occupation suggests a notable difference between genders, with men having significantly longer tenures than women. This could contribute to the observed income gap, as longer occupational tenure often correlates with higher earnings and stability.

These statistics highlight key socioeconomic patterns that underlie the analysis: persistent gender income inequality, limited e-commerce adoption, and differential impacts of the pandemic across demographic groups.

Table 2 highlights findings across three model specifications: unstandardized levels, standardized levels, and logarithmic income transformations. Also presents the regression results, showcasing the direction, magnitude, and statistical significance of critical variables, as well as goodness-of-fit measures (R^2 values).

Table 2: Panel Results. Dependent variable: Income from the main activity. Fix affects[1] 2018-2022

	Level	**Standardized**	**Log**
Lagged Income	-0.079***	-0.079***	-0.269***
	(0.034)	(0.034)	(0.041)
Post-COVID	-1136**	-0.080**	-0.042
	(507.874)	(0.036)	(0.151)
E-commerce Adoption	13761***	0.973***	0.981***
	(5233)	(0.370)	(0.269)
Post-COVID × E-commerce	-16545***	-1.170***	-1.626***
	(5718.038)	(0.404)	(0.451)
Female	-4742***	-0.335***	-0.0235***

[1] The Hausman test about the suitability of fixed effects over random effects can be found in the annex.

	(1170.122)	(0.083)	(1170.122)
Post-COVID × Female	-1094	-0.077	0.129
	(616.199)	(0.044)	(0.171)
E-commerce × Female	-18709***	-1.323***	-0.972***
	(5563.789)	(0.393)	(0.341)
Post-COVID × E-commerce × Female	23423***	1.656***	1.695***
	(6263.737)	(0.443)	(0.545)
Goodness-of-Fit			
Within R^2	0.044	0.044	0.136
Between R^2	0.011	0.011	0.14
Overall R^2	0.06	0.06	0.02
Observations	11,371	11,371	11,371
Number of Groups	3,952	3,952	3,952

*Note: Standard errors are in parentheses. ***, *, and * denote statistical significance at the 1%, 5%, and 10% levels, respectively.

E-commerce adoption significantly increased income levels during the pre-COVID period, as reflected by the positive and statistically significant coefficient on the e-commerce adoption variable in all three models (13761 in Model 1, 0.973 in Model 2, and 0.981 in Model 3). This result underscores the substantial baseline economic benefits of engaging with digital platforms. However, the interaction term between post-COVID and e-commerce adoption reveals a negative and significant coefficient across models (-16545 in Model 1, -1.170 in Model 2, and -1.626 in Model 3), indicating that while e-commerce was beneficial in general, its relative advantage declined for some groups during the pandemic. Reflecting potential challenges such as supply chain

disruptions, increased competition, or barriers to effectively leveraging e-commerce platforms during the pandemic. Due to supply chain disruptions (Suwandi et al., 2022).

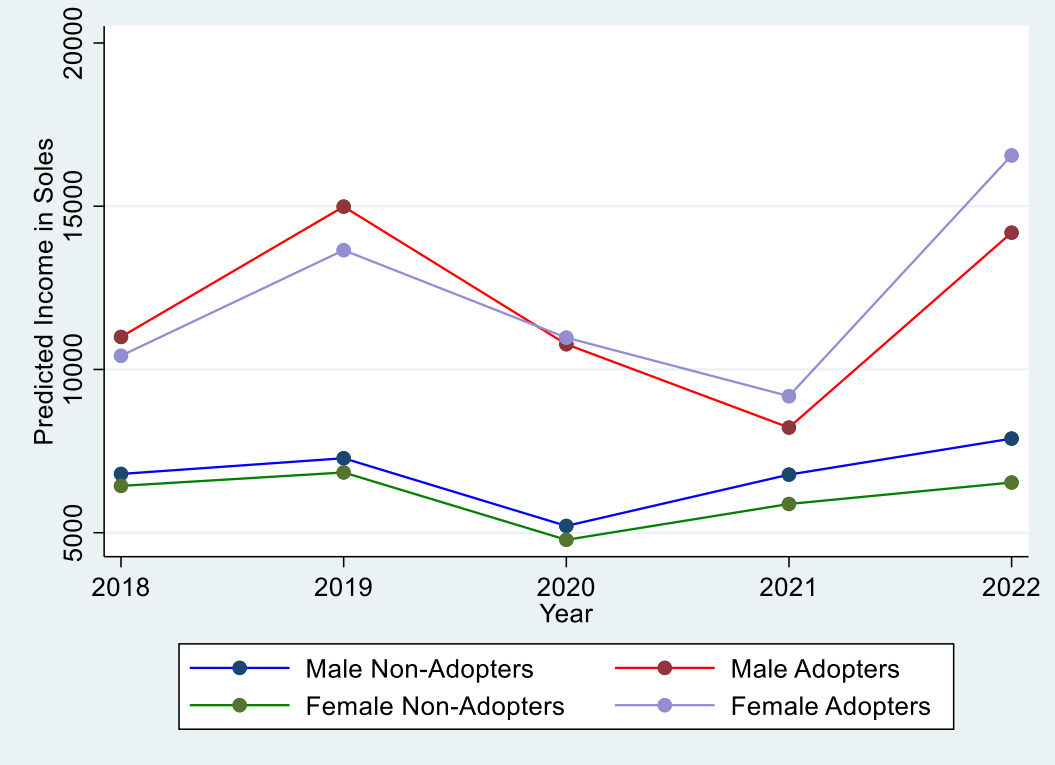
Lagged income exhibits a negative and significant coefficient in all specifications, confirming that autocorrelation exists in income dynamics. This suggests that current income levels are partly influenced by previous periods, reinforcing the need for including this variable to account for persistence effects.

Including the triple interaction term—post-COVID × e-commerce adoption × female—reveals critical insights into gender-specific impacts. The coefficient on this interaction is positive and significant across all models (23423 in Model 1, 1.656 in Model 2, and 1.695 in Model 3), highlighting that women who adopted e-commerce experienced greater income resilience and growth during the pandemic than men. This finding is particularly noteworthy as it suggests that e-commerce adoption mitigated some of the gendered economic disparities exacerbated by COVID-19.

In contrast, the coefficient on e-commerce × female is negative and significant (-18709 in Model 1, -1.323 in Model 2, and -0.972 in Model 3), indicating that pre-COVID, women faced more significant barriers to benefiting from e-commerce than men. However, the post-COVID × female interaction term is not statistically significant in any specification, suggesting that the pandemic did not independently alter gender disparities among non-adopters.

For visual clarity, figure 2 shows estimated income trends across groups over time and the distribution of e-commerce adoption by gender and post-COVID status.

Figure 2. Estimate income Trends Over Time by Group



Robustness Checks

Our first robustness check is with an alternative Timing of the post-COVID period. So, we redefined the post-COVID indicator to start in 2021. We apply the exact estimation and specification from above. The results are shown in Table 3.

Table 3: Comparison of Regression Results: Original vs. Redefined Post-COVID Period (2021 Start)

Variable	Original Results		Redefined post-COVID (2021)	
	Coefficient	Std. Error	Coefficient	Std. Error
Lagged Income	-0.079***	(0.034)	-0.076**	(0.034)
Post-COVID	-1136**	(507.874)	80.39	(464.118)
E-commerce Adoption	13761***	(5233)	10755**	(4683)
Post-COVID × E-commerce	-16545***	(5718.038)	-13910**	(5374.675)

Female	-4742***	(1170.122)	-4391***	(1153.503)
Post-COVID × Female	-1094	(616.199)	-837.13	(542.953)
E-commerce × Female	-18709***	(5563.789)	-14183***	(4934.800)
Post-COVID × E-commerce × Female	23423***	(6263.737)	19604***	(5948.542)

Goodness-of-Fit	**Original**	**Redefined**
Within R^2	0.044	0.043
Between R^2	0.011	0.009
Overall R^2	0.006	0.004
Observations	11,371	11,371
Number of Groups	3,952	3,952

*p 0.1, **p 0.05, ***p 0.01. Robust standard errors are in parentheses.

In the original model, the post-COVID coefficient (-1136) indicates a significant drop in income post-pandemic; however, when the post-COVID period is redefined to 2021, this effect becomes statistically insignificant (80.39). The results suggest that the immediate effects of the pandemic (2020) had a more substantial negative impact on income than delayed effects starting in 2021. E-commerce adoption consistently emerges as a positive force, helping individuals mitigate income losses, particularly for women. However, the negative interaction between post-COVID and e-commerce suggests challenges in fully realizing these benefits during periods of economic uncertainty, possibly due to supply chain disruptions or increased competition (Suwandi et al., 2022).

In the placebo test, our time framework was restricted to pre-COVID years (2018–2019) to ensure that pre-existing trends did not drive observed effects. The results are shown in Table 4

Table 4: Comparison of Original Results and Placebo Test Results

Variable	Original Results		Redefined post-COVID (2021)	
	Coefficient	Std. Error	Coefficient	Std. Error
Lagged Income	-0.079***	(0.034)	-	-
Post-COVID (or Placebo Post-COVID)	-1136**	(507.874)	518.763	(551.408)
E-commerce Adoption	13761***	(5233)	1191.131	(4006.852)
Post-COVID × E-commerce	-16545***	(5718.038)	3353.978	(5915.566)
Post-COVID × Female	-1094	(616.199)	667.955	(581.915)
E-commerce × Female	-18709***	(5563.789)	5125.184	(5115.311)
Post-COVID × E-commerce × Female	23423***	(6263.737)	-11258.58	(7145.071)

*** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$. Robust standard errors are in parentheses.

The interaction terms and other related ones are statistically insignificant. This suggests that no significant income changes were associated with e-commerce adoption during the pre-COVID period (2018–2019). These results imply that trends do not drive the significant effects observed in the original analysis (post 2020) before the pandemic but are likely causal impacts of the pandemic and e-commerce adoption.

Conclusions

These results confirm a positive relationship between e-commerce adoption and income levels, aligning with studies from China and Bangladesh (Uddin & Barua, 2024; Masum et al., 2022; Wang et al., 2024; Liu & Ma, 2016). The significant positive coefficient for e-commerce adoption suggests that digital platforms enable women

entrepreneurs to manage household responsibilities while earning income, fostering economic independence. This finding resonates with the Technology Acceptance Model (Davis, 1989) and the Theory of Planned Behavior (Ajzen, 1985), emphasizing digital platforms' transformative potential to empower women economically.

However, the negative interaction between post-COVID and e-commerce adoption highlights challenges faced during the pandemic. Unlike findings from Mauritius and Nagaland, where e-commerce stabilized incomes by expanding market reach (Kasseeah, 2023; Menon, 2022), income declines among adopters in Peru suggest structural issues, such as supply chain disruptions and limited digital infrastructure. These barriers align with South African research, highlighting rural women's difficulties in engaging effectively with e-commerce (Donga & Chimucheka, 2024). Peru's rural-urban divide, where rural women face more pronounced digital exclusion, may exacerbate this trend.

The triple interaction term (post-COVID × e-commerce × female) indicates a significant income boost for women adopters during the pandemic, supporting studies from Saudi Arabia and China, where digital financial inclusion enhanced women's economic agency and household bargaining power (Mabrouk & Halid, 2021; Liu et al., 2022). This result aligns with theories suggesting that e-commerce can challenge traditional gender roles and expand opportunities for women in conservative societies (Haq et al., 2021). In Peru, women's increased participation in e-commerce may reflect their adaptability to economic disruptions, particularly in regions with nascent digital infrastructure.

Despite the global relevance of these findings, Peru's socioeconomic dynamics provide unique challenges and opportunities. Gender norms, such as **machismo** and the traditional expectations of women as primary caregivers, limit women's economic

participation in both physical and digital markets. Cultural constraints, coupled with lower average education levels for women, as seen in this study, likely restrict women's access to higher-income opportunities, aligning with similar findings in Bangladesh (Masum et al., 2022; Uddin & Barua, 2024).

The significant income gap between male and female adopters before COVID-19 suggests entrenched inequalities in Peru. Women's economic disadvantages pre-COVID reflect broader structural issues, such as lower access to digital tools and entrenched social norms, consistent with global findings (Hendriks, 2019). In rural Peru, limited internet connectivity and digital literacy further hinder women's ability to leverage e-commerce opportunities (Najaf et al., 2021). These structural challenges mirror patterns observed in Sub-Saharan Africa (Donga & Chimucheka, 2024).

This study has clear policy implications. Expanding digital infrastructure and improving internet access in rural areas is critical for reducing the barriers to e-commerce adoption in Peru. Investments in digital literacy programs targeted at women, particularly those in underserved regions, can enhance participation and economic outcomes. Lessons from India's self-help groups and ECOWAS strategies highlight the potential of community-based initiatives to promote digital financial inclusion (Sarawagi & Singh, 2024; Akeju, 2024).

Subsidies or microloans for female entrepreneurs could mitigate financial constraints, enabling them to transition to e-commerce platforms. These initiatives would align with the global push for gender equity in financial inclusion, as Suri and Jack (2016) outlined. Public-private partnerships, such as collaborations with telecom companies to reduce internet costs, could further enhance digital access, a critical factor in rural Peru. The Peruvian government has implemented several initiatives to promote e-commerce, recognizing its potential to drive economic growth and enhance women's

economic empowerment. Peru's participation in the SheTrades Outlook program, launched in October 2023 in collaboration with the International Trade Centre (ITC), is a notable effort. This program aims to collect comprehensive trade and gender data to inform inclusive policymaking, fostering a more conducive environment for women entrepreneurs in the digital economy.

The United Nations Conference on Trade and Development (UNCTAD) also conducted an eTrade Readiness Assessment for Peru, providing a detailed analysis of the country's e-commerce ecosystem. This assessment offers guidance to stakeholders on translating findings into actions that benefit Peruvian society, focusing on enhancing digital infrastructure and literacy.

These initiatives align with broader regional efforts, such as the Asia-Pacific Economic Cooperation (APEC) meetings held in Arequipa, Peru, in May 2024. During these meetings, ministers emphasized the importance of women's full and equal participation in the economy and leadership positions, recognizing that such involvement contributes to broader prosperity and competitiveness. They advocated for policies that address gender inequalities and reduce biases, fostering an enabling environment for women in trade and e-commerce.

Incorporating these programs into the discussion highlights the Peruvian government's proactive stance in promoting e-commerce as a tool for women's economic empowerment (Bahri, 2020). These policies aim to create a more inclusive digital economy by addressing structural barriers and enhancing digital literacy, enabling women to leverage e-commerce for financial independence and entrepreneurial growth. This approach aligns with global best practices and addresses the unique socioeconomic challenges women face in Peru, thereby contributing to more equitable economic development.

This study contributes to the growing literature on e-commerce's gendered impacts by examining women's unique challenges in developing regions like Peru. While e-commerce presents significant opportunities, persistent barriers limit its potential to reduce gender disparities. Future research should explore interventions tailored to Peru's socioeconomic realities, such as culturally sensitive training programs or region-specific policies to close the digital divide. Addressing these gaps is essential for fostering inclusive growth and ensuring digital transformation's benefits reach all demographic groups.

By grounding the findings in Peru's socioeconomic context and comparing them with global trends, this discussion provides actionable insights for policymakers. Implementing targeted interventions can amplify e-commerce's potential to empower women, reduce gender disparities, and drive equitable economic development.

References

Akeju, K. F. (2024). Gender and digital financial inclusion: Assessment of rural/urban dichotomy in microfinance and table banking operations in ECOWAS. In Sustainable Development Goals series (pp. 123–133). https://doi.org/10.1007/978-3-031-53337-2_11

Astarloa, B. D. de, Mulder, N., Santamaria, S. C., Weck, W., Barreiros, L., Huerta, R. C., Patiño, A., & Gómez, M. (2021). Post pandemic COVID-19 economic recovery: Enabling Latin America and the Caribbean to better harness e-commerce and digital trade (No. 00881; Discussion Paper). https://www.cepal.org/apps

Ajzen, I. (1985). Action control: From cognition to behavior. In From intentions to actions: A theory of planned behavior. Springer.

Akther, F. (2023). E-commerce in India: Trends, hurdles, and growth opportunities. PT Formosa Cendekia Global. https://doi.org/10.55927/fjst.v2i10.6152

Alarifi, A. A., & Husain, K. S. (2023). The influence of Internet banking services quality on customer's satisfaction of Saudi banks: Comparison study before and

during COVID-19. International Journal of Quality & Reliability Management, 40, 496–516.

Afshan, G., Shahid, S., & Tunio, M. N. (2021). Learning experiences of women entrepreneurs amidst COVID-19. International Journal of Gender and Entrepreneurship, 13(2), 162–186.

Angelov, N., & Waldenström, D. (2023). COVID-19 and income inequality: Evidence from Sweden. Journal of Economic Inequality, 21, 1–29.

Bala, D. M. R. G. (2024). Digital banking and financial inclusion for financial empowerment of women. International Journal For Multidisciplinary Research. https://doi.org/10.36948/ijfmr.2024.v06i02.16471

Bahri, A. (2020). Women at the frontline of COVID-19: Can gender mainstreaming in international trade help? Journal of International Economic Law, 23(3), 563–582.

Bejaković, P., & Mrnjavac, Ž. (2020). The importance of digital literacy on the labour market. Employee Relations: The International Journal, 42(4), 921–932.

Belho, K., & Konwar, D. (2024). A descriptive study on digital banking and financial inclusion of women self-help groups in Nagaland. Deleted Journal, 2(06), 1956–1960. https://doi.org/10.47392/irjaem.2024.0289

Braun, P., Birdthistle, N., & Flynn, A. (2023). Beyond COVID-19: Women entrepreneurs and e-commerce policy in the Asia-Pacific. In Women's Entrepreneurship Policy (pp. 192–213). Edward Elgar Publishing.

Davis, F. D. (1989). Perceived usefulness, perceived ease of use, and user acceptance of information technology. MIS Quarterly, 13, 319–340.

Demirgüç-Kunt, A., Klapper, L., Singer, D., & Ansar, S. (2022). The Global Findex Database 2021: Financial inclusion, digital payments, and resilience in the age of COVID-19. World Bank Publications.

Dumanska, I., Hrytsyna, L., Kharun, O., & Matviiets, O. (2021). E-commerce and M-commerce as global trends of international trade caused by the COVID-19 pandemic.

Donga, G., & Chimucheka, T. (2024). COVID-19 pandemic digitisation lessons for rural women-owned micro and small enterprises. International Journal of Business Ecosystem & Strategy, 6(3), 93–105. https://doi.org/10.36096/ijbes.v6i3.494

Elzahi Saaid Ali, A. (2022). Empowering women through Islamic financial inclusion in Comoros. In Empowering low-income people through financial and social inclusion in Africa: An Islamic perspective (pp. 49–72). Springer.

Fungáčová, Z., & Weill, L. (2015). Understanding financial inclusion in China. China Economic Review, 34, 196–206.

Graeber, T., Koch, M., & Hiller, L. (2021). Gender disparities in income loss among self-employed women in Germany during COVID-19. German Economic Review, 18(3), 215–230.

Haq, M., Victor, S., & Akram, F. (2021). Exploring the motives and success factors behind female entrepreneurs in India. Quality & Quantity, 55, 1105–1132.

Hendriks, S. (2019). The role of financial inclusion in driving women's economic empowerment. Development Practice, 29, 1029–1038.

Kabeer, N. (1999). Resources, agency, achievements: Reflections on the measurement of women's empowerment. *Development and change*, *30*(3), 435-464.

Kanyaru, P. M., & Kyalo, J. K. (2015). Factors affecting the online transactions in the developing countries: A case of e-commerce businesses in Nairobi County, Kenya. Journal of Educational Policy and Entrepreneurial Research, 2(3), 1–7.

Khan, M., Xu, X., Dou, W., & Yu, S. (2016). OSaaS: Online shopping as a service to escalate e-commerce in developing countries. In Proceedings of the 2016 HPCC/SMARTCITY/DSS International Conference (pp. 1402–1409). https://doi.org/10.1109/HPCC-SMARTCITY-DSS.2016.0200

Li, Y., & Zhou, L. (2023). E-commerce development, time allocation and the gender division of labour: Evidence from rural China. Applied Economics Letters, 1–6.

Lestari, D., Za, S. Z., Maria, S., Wardhani, W., & Yudaruddin, R. (2021). The impact of COVID-19 pandemic on performance of small enterprises that are e-commerce adopters and non-adopters. Problems and Perspectives in Management, 19(3), 467–477. https://doi.org/10.21511/PPM.19(3).2021.38

Liu, Y., & Ma, H. (2016). The financial empowerment of women entrepreneurs through e-commerce in China. Asian Economic Journal, 30(2), 167–184.

Liu, Y., Wei, J., & Xu, J. (2022). COVID-19 and financing constraints in China: A blessing or a curse? Finance Research Letters, 44, 102048.

Mabrouk, F., & Halid, N. (2021). Inclusive finance and income inequality: An evidence from Saudi Arabia. In Financial inclusion in emerging markets (pp. 311–327). Singapore.

Mabrouk, M., Al-Haddad, T., & Ahmed, S. (2023). Digital financial inclusion and women's economic empowerment in Saudi Arabia. Journal of Economic Policy, 30(1), 123–140.

Masroor, N., Asim, M., & Hussain, S. (2020). E-commerce: A gateway to mobilizing female entrepreneurs in the digital era. International Journal of Advance Science and Technology, 29(10), 1–17.

Masum, A., Rahman, M., & Hossain, R. (2022). Efforts by women to become financially independent through e-commerce during COVID-19: A study on Bangladesh perspective. Journal of Economic Studies, 55(3), 214–232.

Mohammad, A. M., Truong, H. T., & Sonobe, T. (2021). Changes in the rural economy in Bangladesh under COVID-19 lockdown measures: Evidence from a phone survey of Mahbub Hossain sample households. In Research Papers in Economics (Número 1235). https://www.adb.org/sites/default/files/publication/689246/adbi-wp1235.pdf

Morell, M. F. (2022). The gender of the platform economy. Internet Policy Review, 11(1), 1620–1640.

Najaf, K., Subramaniam, R., & Atayah, O. F. (2021). Understanding the implications of FinTech peer-to-peer (P2P) lending during the COVID-19 pandemic. Journal of Sustainable Finance and Investment. https://doi.org/10.1080/20430795.2021.1917225

Nghargbu, R., & Jumare, F. (2024). Digital financial inclusion for women in Africa: Prospects and challenges. In Sustainable Development Goals series (pp. 115–122). https://doi.org/10.1007/978-3-031-53337-2_10

Ngo, C. N. (2022). Foundations of rural resiliency: America during the COVID-19 pandemic. Journal of Rural Studies, 96, 305–315. https://doi.org/10.1016/j.jrurstud.2022.10.022

Nitika. (2023). E-commerce and possible challenges in developing countries. Asian Journal of Management and Commerce. https://doi.org/10.22271/27084515.2023.v4.i2b.204

Odoch, H. J., Namono, R., & Wofuma, G. (2024). Enhancing financial resilience of women-owned SMEs in the aftermath of COVID-19 pandemic: The antecedent role of social capital. Vilakshan-XIMB Journal of Management.

Ojo, T. A. (2022). Digital financial inclusion for women in the Fourth Industrial Revolution: A key towards achieving Sustainable Development Goal 5. African Review, 14, 98–123.

Pejić-Bach, M. (2021). Editorial: Electronic commerce in the time of COVID-19. Journal of Theoretical and Applied Electronic Commerce Research, 16(1), 1–15.

Popescu, C. R. G. (2022). Fostering creativity in business: Empowering transformational solid leaders. In Handbook of research on changing dynamics in responsible and sustainable business post-COVID-19 era (pp. 349–381). IGI Global.

Rahman, M. S., Haque, M. E., Afrad, M. S. I., Hasan, S. S., & Rahman, M. A. (2023). Impact of mobile phone usage on empowerment of rural women entrepreneurs: Evidence from rural Bangladesh. Heliyon, 9(11).

Rogers, E. M. (2010). Diffusion of innovations. Simon and Schuster.

Sarawagi, A., & Singh, M. S. (2024). Empowering women: E-Shakti's impact on self-help groups digitization and financial inclusion in India. Asian Journal of Economics, Business and Accounting. https://doi.org/10.9734/ajeba/2024/v24i51303

Sen, A. (1999). Development as Freedom. Oxford University Press.

Suri, T., & Jack, W. (2016). The long-run poverty and gender impacts of mobile money. Science, 354, 1288–1292.

Sutejo, B., Lazuardi, D., Lubis, R., Rahmadani, R., & Aziz, D. A. (2022). The role of e-commerce in increasing MSME income in the COVID-19 pandemic (Survey on MSME in Medan City). Journal of Economics, Finance and Management Studies, 5(08), 2174–2181.

Suwandi, M. S., Werdani, R. E., & Kurniawati, N. I. (2022). Impact analysis of COVID-19 pandemic on e-commerce in Indonesia business and recovery strategies in the era of new normal. Asian Journal of Life Sciences, Management and Technology, 1(1), 16–24. https://doi.org/10.14710/ajlm.2022.14297

Torres, J., Maduko, F., Gaddis, I., Iacovone, L., & Beegle, K. (2023). The impact of the COVID-19 pandemic on women-led businesses. The World Bank Research Observer, 38(1), 36–72.

United Nations Conference on Trade and Development (UNCTAD). (2021). COVID-19 and e-commerce: A global review. Retrieved from https://unctad.org/publication/covid-19-and-e-commerce-global-review

Van Dijk, J. (2020). *The digital divide*. John Wiley & Sons.

Verma, A., & Kumar, S. (2021). Entrepreneurship amidst pandemic COVID-19. Book Rivers.

Venkatesh, V., & Morris, M. G. (2000). Why don't men ever stop to ask for directions? Gender, social influence, and their role in technology acceptance and usage behavior. MIS Quarterly, 24(1), 115–139.

Wang, X., Liu, S., & Liu, R. (2024). E-commerce development and women's family empowerment: Evidence from China. Applied Economics Letters, 1–5.

W, S. S. S., & Hangarki, S. B. (2024). A study on the role of open banking in women empowerment through SHGs in India. International Journal of Innovative Science and Research Technology, 1031–1033. https://doi.org/10.38124/ijisrt/ijisrt24jul1105

Wani, B. A., & MohamadAli, N. A. B. (2022). COVID-19 sparked the e-commerce revolution; some benefited, while others left in cold. International Journal of Computer Science and Information Technology, 14(03), 111–117. https://doi.org/10.5121/ijcsit.2022.14309

Zhou, Y., & Wang, L. (2021). The impact of COVID-19 on women's participation in e-commerce: A global perspective. Journal of Business Research, 130, 1–10.

Zhang, Y., & Wang, L. (2020). The impact of COVID-19 on women's participation in e-commerce: A global perspective. Journal of Global Marketing, 33(3), 215–230.

Annex 1. Hausman test

Variable	(b) fixed	(B) random	(b-B) Difference	S.E.
Income lagged	-0.11	0.42	-0.52	0.01
1.post covid	-411.88	552.97	-964.85	242.99
1.ecommerce	9151.91	7130.23	2021.68	1290.58
post covid#ecommerce in	-9750.07	-5984.64	-3765.43	1336.08
1.female	-4836.05	18.43	-4854.49	10108.05
post covid#female	-716.41	-683.76	-32.65	105.45

e-commerce _in#female	-8564.29	-4494.97	-4069.32	1844.24
post covid#ecommerce#female	9679.32	6093.57	3585.76	1823.78

b = consistent under H_0 and H_a; obtained from xtreg

B = inconsistent under H_a, efficient under H_0; obtained from xtreg Test: H_0: difference in coefficients not systematic $\chi^2(20) = (b - B)'[V_{b-B}]^{-1}(b - B) = 102.75$ there fore Prob > $\chi^2 = 0.0000$