

Bridging the Gender Gap in Entrepreneurship and Empowering Women via Digital Technologies*

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Undergoing internal approval; do not circulate publicly.

First draft: April 2022; this draft: September, 2022

Abstract

Female entrepreneurs are underrepresented in many developed and developing countries for various cultural, historical, and economic reasons. Using primarily collected online and offline enterprise surveys, universal business registration records, and transactions from a world leading e-commerce platform, we document a gender gap in entrepreneurship in China and investigate whether digitization reduces it. Specifically, we show that the expansion of e-commerce and digital marketplaces mitigate constraints faced by female entrepreneurs and business owners by enabling work flexibility and drastically amplifying the distributional channels of their companies. Consequently, female entrepreneurial entry and performance improve, both in absolute terms and relative to men. Moreover, against the backdrop of the COVID-19 pandemic, women are more likely to adopt e-commerce and other digital technologies, with implications for long-term business operations, performance, and resilience.

Keywords: COVID-19, Digital Platforms, Entrepreneurship, Gender

*We thank Lixing Li and Xuanli Xie for detailed feedback. We also thank conference and seminar participants at Peking University for helpful comments and discussions. This research was funded in part by China Natural Science Foundation (Project No. 71874008, 71441008, 71873121, and 72192844), Peking University, the Ewing Marion Kauffman Foundation, the Fintech Chair at Paris-Dauphine University-PSL, and the FinTech at Cornell Initiative. The contents of this article are solely the responsibility of the authors. We are grateful to the leadership at JD.com for providing us access to their desensitized data, and to Yuetong Meng and Tyler Parente for excellent research assistance.

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1 Introduction

Entrepreneurship is a key driver of economic growth and job creation (Baumol, 1996; Fonseca et al., 2001; Li et al., 2009). However, the female participation rate in entrepreneurial activities is significantly lower than men's (Kim et al., 2005). About one-third (34%) of large and small businesses globally, for which statistics are available, are owned by women.¹ Moreover, female entrepreneurs are more likely to work in the informal sector, and their businesses are smaller in size.²

There is a large body of literature explaining the gender gap in entrepreneurship. Inadequate access to external financing has been regarded as a major impediment to women entrepreneurs (Greene et al., 2001; Becker-Blease and Sohl, 2007; Brooks et al., 2014; Sauer and Wilson, 2016; Guzman and Kacperczyk, 2019; Ewens and Townsend, 2020). Some innate gender differences, such as in risk preference, are another frequently mentioned contributing factor (Croson and Gneezy, 2009; Bertrand et al., 2010; Klapper and Parker, 2011). Lack of social network and unfavorable social institutions are also listed as limiting factors (Field et al., 2010; Howell and Nanda, 2019). More family obligations restrict women's occupational choices, including entrepreneurial activities (Bertrand et al., 2010; Core, 2020; Zandberg, 2021)

Removing impediments to women's participation in entrepreneurial activities can help improve resource misallocation and reduce talent distortions (Hsieh et al., 2019). Various policy options have been proposed to tackle these constraints facing women entrepreneurs across the world. However, it is hard to overcome these challenges and boost up female entrepreneurship in a short time using the traditional means. One option is to look at countries with rapid improvement in female entrepreneurship and examine the underlying drivers. Our paper focuses on China, a country with rapid rise in women entrepreneurs.

According to the business registration dataset maintained by the China's State Administration for Market Regulation, between 2012 and 2021, the number of private enterprises in China grew from about 10 million to nearly 45 million, quadrupling in 10 years, and the share of private enterprises in the total number of enterprises increased from 79.4% to 92.1%. In the same period, the share of female entrepreneurs increased from 16% to 28%. The 2021 Hurun Global Rich Women's List also reports that "China has two-thirds of the world's

¹The statistical criterion is "at least one woman as the primary owner (one of them)." For details, please see <https://blogs.worldbank.org/opendata/women-entrepreneurs-needed-stat>.

²For details, please see <https://www.endvawnow.org/en/articles/1957-women-in-the-informal-economy.html>.

most successful women entrepreneurs.”³ As a comparison, about 19.1% of small businesses in the US are owned by women.⁴ In the period from 2014 to 2020, the share of female entrepreneurs worldwide has barely increased by 2 percentage points according to the We-Data project.⁵ What are the drivers behind the rapidly rising female entrepreneurship in China and narrowing gender gap?

The major explanations mentioned above on gender gap in entrepreneurship do not seem to be good answers to the question. First, in the past several decades, there have been no special policies in China targeting female entrepreneurs for credit support. The existing gender bias against female entrepreneurs in access to traditional external credit, if at all, have not changed much. Thereby, this channel can hardly explain the surge in female entrepreneurship. Second, some innate gender differences, such as risk preference, change little over time. They may explain the existence of gender gap in entrepreneurship, but not trend of narrowing gap. Third, it is hard to attribute the rising female entrepreneurship to change in social norms, such as a shift in balance in favor of work over family. If there is such a shift, we would observe a rising female labor force participation rate, because women generally prefer stable formal employment to informal employment and entrepreneurial activities as shown in the literature (Carranza et al., 2018). In fact, China’s female labor force participation rate has declined in the past several decades (Ke et al., 2012). Therefore, there must be some other factors at play.

We put forth a hypothesis that the growth of e-commerce and other digital economies is an important factor in driving up female entrepreneurship in China. In the past two decades, e-commerce in China had also grown from scratch and became the world’s largest e-commerce market (Cong et al., 2021). More than 40% of the online stores on Alibaba’s e-commerce platform are run by women, higher than in the traditional sectors.⁶ The State Council Information Office’s white paper “Gender Equality and Women’s Development in China” reports that women account for 55% of entrepreneurs in the Internet sector.

The booming e-commerce sector may have contributed to the rising female entrepreneurship in China for at least two reasons. First, in the era of e-commerce and digital economy, women entrepreneurs’ financial constraints have been lessened. Lenders can use Fintech

³For details, please see <https://www.hurun.net/zh-CN/Info/Detail?num=3ASGLVPLSLO5>.

⁴For details, please see <https://www.census.gov/newsroom/press-releases/2020/annual-business-survey-data.html>.

⁵<https://blogs.worldbank.org/developmenttalk/we-data-measuring-gap-female-entrepreneurship-around-world>.

⁶For related coverage, see <http://www.aliresearch.com/ch/information/informationdetails?articleCode=21738>

models to extend online credit to many micro and small enterprises with digital footprints, which were previously underserved by traditional banks due to the lack of collaterals. Because women entrepreneurs account for a larger share in online businesses than in traditional sectors, and Fintech is gender blind in extending credit, a greater number of female entrepreneurs have naturally gained access to online credit (Zeng and Zhang, 2020). In addition, e-commerce can lower the threshold to start a business, which particularly benefits women entrepreneurs as they are more financially constrained.

Second, the mode of e-commerce relies less on social networks. Considering that women generally have less access to business networks than men, the expansion of e-commerce can help women compensate for the lack of social networks and educational opportunities, thus reducing or avoiding the discriminatory treatment encountered in traditional businesses (Xie et al., 2018; Ma & Hu, 2022).

Third, many e-commerce shops are operated at home, which can help women entrepreneurs to balance family and work obligations. Thanks to the digital technologies, some of the constraints have become less binding for women entrepreneurs in the age of digital economy.

To test the hypothesis, we used a combination of administrative and survey data, including business registration database, Jingdong e-commerce transaction data, and online and offline survey data on micro and small-sized enterprises. Textual analysis is used to predict the gender of entrepreneurs based on their Chinese names contained in the business registration database, from which the proportion of female entrepreneurs and executives by sector and region can be tabulated. The result shows a clear upward trend of female entrepreneurship in the past two decades.

Second, in order to draw a causal inference on the impact of e-commerce expansion on female entrepreneurship, we employ Jingdong e-commerce transaction data and take advantage of the rolling out of “Jingdong Bang” program to construct Bartik instrumental variables. The instrumental variable estimation results are consistent with the OLS estimates, validating our hypothesis. Because female-run e-commerce online stores tend to employ more female full-time employees, the e-commerce expansion also has a positive spillover effect on female employment. Third, women entrepreneurs are more likely to adopt e-commerce and other digital means to cope with COVID-19 restrictions than their men counterparts.

Our paper contributes to several strands of literature. First, it is related to literature on gender equality. As shown in the Global Gender Gap Report 2021, published annually by the World Economic Forum since 2006, the gender gap has been closed globally in education (95%) and health (96%), but significant gaps remain in dimensions such as economic partici-

pation and business opportunities (58%).⁷ In particular, the gender gap in entrepreneurship remains alarmingly large. Our paper provides evidence that the gap can be potentially narrowed in the era of digital economy.⁸

The remainder of the paper is organized as follows. Section 2 briefly summarizes the literature on the motivations and performance of female entrepreneurship. Section 3 discusses major data sources and the gender inference algorithm based on Chinese name text, before reporting the overall distribution and trends of women’s entrepreneurship in China. Section 4 presents the identification strategy and empirical results, showing the positive effects of e-commerce expansion on female employees’ employment participation. Section 5 further demonstrates that women entrepreneurs are more likely to adopt digital business tools such as e-commerce to cope with the Covid restrictions. Finally, section 6 concludes with a summary and discussion.

Literature. Our study contributes the understanding of the gender gaps in behavior and economic outcomes in general (career path, pay, etc.; see, e.g., Bertrand et al., 2010; Kagel and Roth, 2020, chapter on “Gender”), and those concerning entrepreneurship in particular (e.g., success rate, financial support; see Klapper and Parker, 2011; De Vita et al., 2014).

Some studies identify gender gap between female and male entrepreneurs and attribute it to differences in preference, innate or acquired, using psychological and economic experiments (e.g., Croson and Gneezy, 2009; Marianne, 2011). Notably, studies point out that women are more risk averse (Eckel and Grossman, 2008; Croson and Gneezy, 2009; Dohmen et al., 2011; Charness and Gneezy, 2012) and therefore have a lower propensity to start a business or take risks in executive positions (Koellinger et al., 2013; Huang and Kisgen, 2013). Risk aversion in women may be caused by genetic differences (Sapienza et al., 2009; Guiso and Rustichini, 2018), such as the difference in testosterone production levels, or the environment (Booth et al., 2014), both of which affect risk-taking.⁹ (Over-)confidence is also shown to explain the gender gaps in the willingness to compete (e.g., Niederle and Vesterlund, 2007; Croson and Gneezy, 2009), speak up (Coffman, 2014), and be a leader (Born et al., 2018), the inclination to self-promote (Exley and Kessler, 2022) or be motivated under competitive environment (Gneezy et al., 2003), and the performance evaluation (Exley and Nelsen, 2022), especially

⁷<https://www.mastercard.com/news/media/1ulpy5at/ma_miwe-report-2020.pdf>.

⁸<https://www.ebaymainstreet.com/empowering-women-sellers-report>.

⁹In terms of altruistic preferences, women are more inclined to express concern and responsibility for the well-being of others (Beutel and Marini, 1995). As a result, women are generally more willing to donate (Andreoni and Vesterlund, 2001), more friendly to employees Tate and Yang (2015).

in executive roles or entrepreneurial activities (Bengtsson et al., 2005; Niederle et al., 2011; Huang and Kisgen, 2013). These have led to limited female entrepreneurship (Bönte and Piegeler, 2013) and poor SME performance (Amore and Garofalo, 2016). Moreover, due to homophily preferences, studies have found that homogeneity in gender, race, and educational background increases the likelihood of team formation but makes women less likely to enter industries dominated by men (Gompers et al., 2017).

Multiple external factors, potentially interacting with intrinsic preferences, also constrain female entrepreneurship. First, existing research identifies financial disincentives as a significant barrier to new firm establishment, and women are subject to greater liquidity constraints (Sauer and Wilson, 2016) and less access to venture capital (Greene et al., 2001; Becker-Blease and Sohl, 2007; Brooks et al., 2014; Guzman and Kacperczyk, 2019; Ewens and Townsend, 2020). Moreover, women-managed companies receive less external equity financing and investment at IPO (Hebert, 2020; Bigelow et al., 2014), in addition to having less access to bank loans and higher interest rates (Muravyev et al., 2009). Indeed, the Sri Lankan experiment shows that financial subsidies and business training promote local women’s entrepreneurial behavior.

Furthermore, family and culture shape women’s entrepreneurial decisions. Childbirth and childcare have a negative effect on women’s willingness to work and their performance but it increases the likelihood of choosing self-employment when deciding to work (Song and Dong, 2018; Guo et al., 2018). This is mainly due to the better flexibility in the form of entrepreneurship or self-employment (Boden Jr, 1999). Bruhn (2009) finds a negative relationship between child rearing and family labor obligations and the size and performance of women entrepreneurs’ firms (Bertrand et al., 2010). It is also noted that career interruptions due to childbirth for women affect their future career development (Core, 2020). Reducing the risk of childbirth was found to help reduce the gender gap in entrepreneurship (Zandberg, 2021). Again, the lack of social networks is a major challenge for female entrepreneurship, as Howell and Nanda (2019) and other studies have found. Environmental factors such as better institutional culture, better rule of law and fairer social norms, social welfare structures, and greater female political participation are all positively associated with female entrepreneurship.

In terms of business performance by female entrepreneurs and executives, the literature has mixed findings. Firms with female executives or directors are shown to have lower financial indicators (e.g., profits), but female executives or directors perform better on certain issues involving risk (Jayachandran, 2021). In Latin America, female-owned businesses tend

to be smaller than male-owned businesses in terms of employees, sales, costs, and physical capital (Bruhn, 2009). The average impact of board gender diversity on firms is also negative (Adams and Ferreira, 2009), as seen in the Norwegian data, leading to lower share prices, Tobin’s Q, board professionalism, labor hiring, and short-term profits (Ahern and Dittmar, 2012; Matsa and Miller, 2013). Meanwhile, European data reveal that firms run by women are less leveraged, have less volatile earnings, and have a higher chance of surviving (Faccio et al., 2016). In the United States, women-run firms are also less likely to engage in acquisitions, debt issuance and on on (Huang and Kisgen, 2013). Female-managed banks were also found to have significantly better financial performance in low-competition environments but tended to underperform when competition increased.

None of the studies highlights the role of technology in mitigating the differences in preferences and the aforementioned constraining factors for women. We are the first to document the effects of digital platforms on the gender gap in entrepreneurship both in terms of choices and outcomes.

2 Data and Institutional Background

2.1 Data Description

Business registration data In this paper, we first use the business registration dataset covering the universe of registered enterprises in China, recorded and digitized by the State Administration for Market Regulation of China (formerly the State Administration for Industry and Commerce, SAIC). It covers all market entities registered with administration agencies at all levels, including basic information about location, sector, date of establishment, registered capital, business operation scope, ownership type, the list of shareholders and managers, and the alteration record. The nature of its universal coverage and the informative record on entrepreneurs’ characteristics makes it a more accurate, representative, and unique data source for investigating female entrepreneurs. It also covers more medium, small, and micro-sized enterprises (MSMEs) than other firm-level databases, which could be more critical to our research topic as women are more prone to start a business in informal sectors. In contrast, the commonly used Annual Survey of Industrial Firms (ASIF) in China covers manufacturing enterprises with annual sales over a threshold of 5 million RMB. It contains most large Chinese firms while leaving out SMEs in the manufacturing sector and all the firms in the service sector that make up the majority of Chinese firms.

Nevertheless, since gender is not publicly presented in the business registration data as it is highly privacy-sensitive, we have developed a machine-learning textual analysis algorithm to infer entrepreneurs' gender from their given names, which will be described in detail in the following subsection.

This paper mainly uses the entry information of newly-built enterprises between 1995 and 2020 from the business registration data, and matches the names and positions of the legal representatives and key business managers corresponding to the newly-established enterprises and applies the algorithm in the next subsection to infer their gender which is used to sum up and calculate the proportion of female entrepreneurs or executives in different regions, times, and industries. To further match the Jingdong e-commerce transaction data, this paper sums up variables such as the number and proportion of female entrepreneurs or executives in new businesses in the corresponding industries in each quarter from 2015 to 2019 for the 214 sampled districts and counties. In addition, this paper incorporates the text identification method for business scope in Cong et al. (2021) to calculate the share of female entrepreneurs and executives in new businesses engaged in e-commerce operations.

Jingdong e-commerce transaction data. To quantitatively analyze the impact of e-commerce expansion on female entrepreneurship, this paper also incorporates Jingdong e-commerce transaction data. As mentioned earlier, the Jingdong e-commerce transaction data includes quarterly panel data on e-commerce platform transactions for a total of 214 districts and counties in different regions of China summed at the regional and product levels from the first quarter of 2015 to the third quarter of 2019. Through the correspondence between industries and product categories (National Bureau of Statistics' Product Classification Catalogue for Statistics), this paper matches the products and services in the e-commerce transaction data with their corresponding processing manufacturing or service industries, thus linking them with business registration data to form a dataset containing both e-commerce platform transaction information and female entrepreneurship. Also, this paper uses sales on the Jingdong platform in the sample districts and counties as a measure of local e-commerce development, the main explanatory variable in the empirical section. This index is the original data source of the county or municipal e-commerce activity indices (mainly e-commerce sales indices) that have been published by relevant organizations, and it can be further refined to the industry level, which makes this "e-commerce index" used in this paper have variability at the county-industry level, and it can be more in-depth than the indices summed at the regional level. This allows for more in-depth empirical testing.

Online Survey of Small and Micro Enterprises in China (OSOME). It is worth noting that the construction of this dataset may be biased due to the potential error of the gender inference algorithm, especially when both the algorithm for identifying the text of the business scope of registered enterprises and the algorithm for inferring gender based on Chinese names are used, the superposition of the errors of the two algorithms may affect the estimation results. Therefore, this paper will also combine with micro data from OSOME for corresponding additional analysis. The quarterly survey on average receives between 10,000 and 20,000 responses each time, with samples including unregistered individual business households, registered self-employed businesses, and incorporated enterprises, etc., among which unregistered individual self-employed businesses account for nearly 40%. The group of unregistered self-employed businesses has been largely neglected and underestimated in previous studies due to lack of data.

The OSOME data is matched with the gender variable in the back-end desensitized registration information. Female micro and small enterprises account for about 17.3% of the sample collected from Q3 2020 to Q4 2021, concentrated in the service industry, and their business types are mostly self-employed (including registered and unregistered), as shown in Figure 1. At the same time, the questionnaire includes questions about micro and small enterprises' business performance, financing, post-Covid-19 recovery, online operation, digital transformation, current major challenges, expectations for the future, and operators' personal basic information, especially if it contains information about digital transformation of micro and small operators in e-commerce, online operation, telecommuting, and electronic information system, which enables this paper to further examine women entrepreneurs' adoption of digital business.

The OSOME data include a few questions on business model (online only, offline only, combined online and offline) and online sales ratio. Furthermore, OSOME data is also matched with the information of registered sellers on Taobao e-commerce platform (taobao.com), making it possible for us to accurately identify the e-commerce operators in the sample based on whether they are registered sellers on Taobao. Considering that the Taobao system occupies a major market share in the Chinese e-commerce market,¹⁰ most e-commerce operators can be identified through this method. At the same time, the unobservability of operators' registration on other platforms will more likely lead to an underestimation of the empirical

¹⁰For related coverage, see <https://www.163.com/dy/article/H0NK2JB00514CA4V.html>.

results in this paper. In the recall sample, the proportion of female operators among Taobao registered sellers is 21.2%,¹¹ which exceeds the average of 17.3% in the sample. In addition, in the empirical analysis section, this paper also excludes small and micro enterprises established after 2019 and the sample from cities hit by the Covid-19 pandemic at the time of the survey to mitigate the impact of the shock of Covid-19 on the relevant indicators. In particular, in the first quarter of 2002, the OSOME questionnaire includes a few questions on female entrepreneurs, such as time allocations between work and household chores, allowing us to examine whether e-commerce operations offer female entrepreneurs more time flexibility. In addition, the OSOME data contains information on the location of MSMEs at the prefectural level, thus allowing us to match the information on sporadic outbreaks and corresponding blockade measures at the prefectural level in the country since the third quarter of 2020, which was manually collected and compiled in this paper, to assess the heterogeneity of the impact of Covid-19 on the adoption of e-commerce and other digital transformation by female and male MSMEs.

[Figure 1 Here]

Survey of Enterprise Innovation and Entrepreneurship in China (ESIEC). ESIEC is sampled from six provinces in China. Although it is meant to be representative in each province, the whole sample ends up resembling the industry distribution and firm size distribution quite well (Dai et al., 2021; Xu, 2022). The field survey conducted between 2017 and 2019 includes questions on online sales. We match the baseline survey data with the registered capital information from the business enterprise registration data to test the underlying mechanism.

2.2 Algorithm to Identify the Gender of Entrepreneurs for Business Registration Database

Although the business registration dataset publicizes the names of the main personnel of registered enterprises, the gender information is not available to the public. To overcome this challenge, we use text analysis and machine learning methods to predict the gender based on the Chinese names of the registered personnel. In China, the surname is mostly inherited

¹¹This percentage is lower than the previously cited report, mainly because the OSOME sample frame is active merchants using Alipay’s payment barcodes, not all of which operate on e-commerce platforms. The 21.2% is representative compared to the backend statistics that meet the definition of “active users”.

from the father. First names are normally picked up by the elders according to various factors such as time, clan, gender, traditional culture (e.g. poetry, zodiac sign, "five elements"), and expectations for the offspring.¹² For example, in the era of family planning, "Zhaodi(招弟)" (wish the next child a brother) is most likely a female name, reflecting a strong son preference. "Zi", "Wan", "Ting" and other names containing the radical "Nv" are mostly given to girls; "Lan", "Zi", "Zhen" and other words that indicate jade, precious flowers, and plants are also mostly used in female names. The Ministry of Public Security's "National Name Report 2010-2020" shows the names most used by men and women systematically vary across generations. For example, among the cohort born during 2010-2019, "Zixuan" ranks the fourth in popularity for both genders. Although their pronunciation is the same, the Chinese characters are actually different between men and women.

There are also relevant studies in the literature that use names to study discrimination, such as Bertrand and Mullainathan (2004) analyzing racial discrimination in the U.S. job market by posting fictitious resumes with similar backgrounds but different names in an experiment. Oreopoulos (2011) finding, through a similar experiment, that the Toronto job market discriminates between applicants with Indian, Pakistani, Chinese and Greek names. Edelman et al. (2017) found that hosts on the Airbnb platform were more likely to reject applications from residents with African-American names, and users with African-American names had longer wait times and were more likely to have their orders canceled on the Uber platform (Ge et al., 2016). Yet Fryer Jr and Levitt (2004) suggested that names may contain expectations of individuals that influence their performance, and that the pronunciation characteristics of English names are better predictors of gender (Cassidy et al., 1999). Some experimental studies have also found that the gender information implicit in names can interfere with performance (Fershtman and Gneezy, 2001; Charness and Gneezy, 2008). This problem is not serious for the application scenario in this paper because Chinese names contain less information related to ethnicity and race. Similarly, the Tang and Zhang (2021) shows the correspondence between Chinese names and gender was calculated using

¹²The Ministry of Public Security of the People's Republic of China's "National Name Report for 2020" summarizes the basic statistical characteristics of Chinese surnames and first names in household registration information. In particular, the report points out that "from the selection of the surnames of newborns in 2020, the ratio of those with their mother's surname to those with their father's surname is 1:12." See http://www.gov.cn/fuwu/2021-02/08/content_5585906.htm.

According to Article 1015 of the Civil Code of the People's Republic of China, except for the traditional cultural customs of ethnic minorities and some special circumstances, "natural persons shall take their father's or mother's surname", please refer to <http://www.npc.gov.cn/npc/c30834/202006/75ba6483b8344591abd07917e1d25cc8.shtml>.

census sampling data and applied to the data of industrial enterprises above the scale to infer the gender of the legal representatives of the enterprises; this paper further uses more training sets to infer the gender of all registered enterprises and incorporates machine learning algorithms on this basis.

With the above cultural and literature base, this paper attempts to infer gender through Chinese names.¹³ Specifically, this paper restricts to samples using Chinese names in business registration data and uses a plain Bayesian model to predict their gender.¹⁴ For text processing, since Chinese surnames are relatively fixed (including compound surnames), the surnames and first names in Chinese names are first decomposed. Since most of the Chinese surnames are single characters, in the actual processing, we first organize the list of compound surnames (e.g. "Ouyang", etc.) and decompose the surnames and first names in the compound surnames. For the remaining single surname samples, we can directly decompose the first Chinese character in their names to get the first names.¹⁵ Further, in this paper, we select suitable Chinese name and gender data as the training set, transform the decomposed name vector into a sparse matrix and apply the plain Bayesian method for training. The training set used in this paper is the public information containing the gender of the main personnel of some registered enterprises before 2015, while the related software also

¹³For English names, relevant websites have also trained gender inference models based on the collected data and provided API interfaces for use, currently supporting 189 countries, but some of them have small sample sizes for the training set. For details, please see <https://gender-api.com/en/>.

¹⁴Due to the relevant legal requirements of registration and reference to the practice of grassroots departments at all levels, the name in the industrial and commercial registration or patent application needs to be consistent with the valid documents of the individual, and even foreigners with Chinese names need to be registered according to their passports and other documents, so the individuals with Chinese names in the database are most likely to be Chinese or other ethnic groups influenced by Chinese culture, and their names are selected to a certain extent to meet the traditional culture and The selection of names also satisfies the traditional culture and laws to some extent.

¹⁵The Dictionary of Chinese Surnames (Jiangxi People's Publishing House) has compiled and included tens of thousands of Chinese surnames from ancient times. It is worth noting that the phenomenon of "pseudo-duplicate surnames", i.e. using both father's and mother's surnames, has emerged in recent years, which may lead to bias in decomposing surnames and names, especially when the name is "father's surname + mother's surname + single character". However, under the principle of plain Bayesian algorithm, this problem can be avoided to a certain extent as long as the word of the surname (e.g. "Li") does not have an obvious gender meaning when it appears in common names; meanwhile, the phenomenon of "pseudo-duplicate surname" has emerged in about the last In addition, "pseudo-duplicate surnames" are not considered as new surnames when registered in the household register. For related reports, see <http://education.news.cn/2021-05/28/c1211176092.htm>

In addition, there are very few cases in which the surname is extended to an existing compound surname based on the single surname of the parents, such as the surname "Ling" as "Linghumou", the surname "Ou" as "Ou" Most of them were influenced by martial arts novels and had some implicit gender preference. Since the sample was unable to observe the names of their parents or children, unfortunately this situation could not be treated, but based on traditional cultural considerations, the proportion of this situation may be minimal.

provides the gender prediction model trained based on the public records of the network,¹⁶ in addition to the 1% sampling data of the population census which contains the required information. The results are generally consistent and robust across algorithms and training sets. Finally, since there are many factors involved in the decision process of naming, some human correction adjustments to the algorithm based on realistic observations are needed. In particular, the algorithm puts more emphasis on the conditional probability of each individual character, but there may be a special connection between two characters in Chinese naming. For example, "Shengnan" and "Ruonan" are mostly used for female names, which carry the expectation of the elders that their daughters will not be inferior to men. "Yanan" and "Zhaodi" are also used for female names showing a strong son preference. Although the word "male" may actually appear more often in such combinations, it is predicted to be a male name when combined with other words such as "Sheng". Meanwhile, when "Nan" is used as a harmonic substitution, the algorithm predicts a male name and the accuracy of the algorithm's prediction decreases when "Nan" is used as a harmonic instead. One improvement method is to add the collocation of different characters to the Bayesian probability model, but this will lead to an exponential increase in computing power due to the large size of the number of single Chinese characters. Therefore, this paper deals with specific examples obtained from realistic observations (especially gender-related) on a case-by-case basis to minimize the bias caused by such special cases.

In the training of the plain Bayesian model, 0.6 is selected as the threshold of the baseline prediction result in this paper, (when predicting a male, the posterior probability of judging a female is less than 40%). The predicted result is either retained or marked as undetermined. After the training of the baseline model and special case adjustment, the accuracy in cross-validation reached 90.0%. Further increasing the model threshold can improve the accuracy, but there will be more samples that cannot be judged, so the baseline results with 0.6 as the threshold are reported in the paper.

After completing the gender inference based on Chinese names, this paper selects the indicators about female entrepreneurship for summation calculation. First, in the dimension of female entrepreneurship, this paper uses the proportion of female entrepreneurs in new enterprises as a measure.¹⁷ The definition of "entrepreneur" varies depending on the focus of the research question (Wang and Keane, 2020). Based on the field research, registration

¹⁶For example, the Python third-party package NGender, see <https://github.com/observerss/ngender> for details.

¹⁷Observations with data less than 500 were excluded because of the sensitivity of changes in female proportions when the total is small. The same uniform treatment was done for the other proportion indicators.

regulations and data characteristics, the definition of "entrepreneur" in this paper is the legal representative of a newly established enterprise. First of all, it was found that the legal representative is usually the core founder (one of the founders) of the enterprise during the fieldwork (Dai et al., 2019). It is also noted that 75% of the legal representatives are also the largest shareholders of the enterprise. At the same time, for a large number of SMEs, only the legal representative is often registered at the time of registration, as it is likely that a full management team has been formed at the time of start-up. In particular, the commercial system reform since 2014 has simplified the registration procedures and increased the number of cases where only the legal representative is registered. Secondly, each registered enterprise in the business registration has a unique legal representative (excluding changes), allowing this paper to establish a better correspondence between the table of key management personnel and the table of basic enterprise information. This definition in this paper is also consistent with Dai (n.d.), Shi et al. (2021), and Chen et al. (2022). Further, as a robustness check, this paper also uses a broader (including key management personnel) or narrower (legal representatives must also serve as key management personnel) definition for the analysis, which has no effect on the empirical results and is also consistent with previous studies (Wang and Keane, 2020). Based on this, this paper mainly reports the statistical results using the definition of "legal representative" in the description section. The proportion of women among key management personnel is classified as a career development indicator. Second, in terms of female career development dimensions, this paper selects the group of executives who are not legal representatives in the business registration and calculates the proportion of women.

2.3 Description of Female Entrepreneurship in China

This section first shows the distribution and changes in the proportion of female entrepreneurs among new firms in China at the provincial level between 1995 and 2020, as Figure 2 shows.

[Figure 2 Here]

As shown in Figure 2, the proportion of female entrepreneurs, as measured by legal representatives, increases from 16.4% in 1995 to 27.6%, consistent with Wang and Keane (2020). According to the World Bank, China's female labor force participation rate declined from

71.8% to 61.8% between 1995 and 2020,¹⁸ indicating that a greater proportion of women who choose to enter the labor market choose to start their own businesses. At the regional level, the proportion of female entrepreneurs was highest in the three northeastern provinces in 1995 (21.4% in Jilin Province) and ranked among the highest in the country through the late 1990s, which may be related to the wave of layoffs of workers in the northeast at that time, as Ge (2014) found. From 2000 onward, the proportion of female entrepreneurs among new enterprises in northern provinces and some southern provinces (mainly in the southeastern coastal region and southwestern region) continued to increase, and by 2005, 71.9% of provincial administrative regions (23) had more than 20% of new entrants as female entrepreneurs. Later, the number of female entrepreneurs in the northwest and south-central provinces also gradually increased, and by 2015, the average proportion of female entrepreneurs reached 25.1%, with 12 provincial administrative regions exceeding 25%, and the difference between provinces narrowing. By 2020, the majority of provinces will have more than 25% female entrepreneurs.

Further, based on the labels of firms engaged in e-commerce obtained using text analysis and machine learning algorithms, this paper calculates the proportion of female entrepreneurs among the new entrants using e-commerce and the trend is shown in Figure 3. Unlike the growth path of the proportion of female entrepreneurs in the full sample, when e-commerce businesses started to appear in the economically developed southern provinces around 2000, the proportion of female entrepreneurs among them already exceeded 21.5% at the beginning. At the same time, e-commerce businesses created by women were first concentrated in the southeastern coastal region (especially in the so-called "postal zone", i.e., Jiangsu Province, Zhejiang Province, and Shanghai), and gradually developed from south to north and from coastal to inland regions, with the proportion of women entrepreneurs in e-commerce businesses reaching 29.4% by 2020.

[Figure 3 Here]

A similar trend is reflected in the proportion of female executives in Figure 4. The proportion of female non-statutory representative executives in new businesses in 2005 and 2020 is shown, and reported separately for all new registrations. The results show that the proportion of female executives is higher in the southeastern coastal provinces and cities

¹⁸Data source: <https://data.worldbank.org.cn/indicator/SL.TLF.CACT.FE.ZS?end=2020&locations=CN&start=1995>, defined as "female labor market participation as a percentage of the female population aged 15 years or older". Although the female labor force participation rate in China is on a declining trend, it is still higher than in Japan (53.2%, 2020), South Korea (53.1%, 2020), and the United States (55.4%, 2020).

where e-commerce is developed earlier, especially in e-commerce-related enterprises at the early stage of development, such as 39.1% on average in six provinces (Shandong Province, Jiangsu Province, Zhejiang Province, Fujian Province, Guangdong Province, and Shanghai) in 2005.

[Figure 4 Here]

In addition, this paper also uses the same method to count the proportion of female inventors in new patent grants and disclosures. The China Patent Database compiles and records information on all types of patents registered (applied for, granted, disclosed, etc.) with the State Intellectual Property Office, including fields such as patent type, inventor, registration agency, date, etc. It is an important reference for studying innovation results.¹⁹ Similar to business registration data, patent data disclose the names of all inventors of each patent, but there is no information about their gender. Therefore, this paper applies the same algorithm to infer the gender of each inventor. When there are multiple inventors, this paper extracts each inventor’s name separately for prediction and calculates the proportion and does not distinguish the contribution between different rankings of inventors (e.g., first inventor vs. other inventors). Based on this, in the dimension of female innovation, this paper calculates the proportion of female inventors in new patent grants and patent disclosures, including invention patent grants, utility model patent disclosures, and design patent disclosures, and assigns different weights to them respectively.²⁰

3 Empirical Analysis

3.1 Empirical Strategy

Our paper uses Bartik’s instrumental variable identification framework based on Jingdong e-commerce transaction data and the “Jingdong Bang” e-commerce promotion program to casually quantify the impact of e-commerce expansion on women’s entrepreneurship in

¹⁹The results of innovation also include business models, performance improvement and even corporate culture building, but patents are among the more direct and easily measured indicators. Correspondingly, some studies also use R&D investment (R&D) and the number of R&D personnel as indicators of innovation investment

²⁰Refer to “China Regional Innovation and Entrepreneurship Index Construction and Spatial Pattern: 1990-2020” and “China Digital Economy Innovation and Entrepreneurship Index: Dynamic Evolution and Spatial Divergence”, both sets of indices are calculated according to the summation of 5:2:1 weights. For details, please see <https://www.cer.pku.edu.cn/tab/zhi-shu-yan-jiu/iriec> and <https://www.cer.pku.edu.cn/tab/zhi-shu-yan-jiu/iriedec>.

China. Cong et al. (2021) provides empirical evidence that an e-commerce promotion program led by Jingdong Logistics ("Jingdong Bang") significantly contributes to the growth of purchase demand on Jingdong's e-commerce platform. Combining this demand shock with inter-regional trade networks allows the construction of a Bartik instrumental variable identification framework to examine the impact of demand shocks on e-commerce platforms on firms that provide the corresponding product or service. Therefore, this paper first follows the Bartik instrumental variable described above here to examine the impact of shocks to e-commerce demand growth on female entrepreneurship, using the expansion of Jingdong's e-commerce platform as an example.

The first stage of the Bartik instrumental variable regression is set as follows.

$$\ln(sales)_{ijt} = \theta_1 \times B_{ijt} + \theta_2 \times (\sum_{d \neq i} \omega_{ijd,t=0}) + \mathbf{X}_{i,t-4}\theta + FEs + \sigma_{ijt}(1)$$

where B_{ijt} is the Bartik instrumental variable constructed according to Paper Three Bartik instrumental variables constructed in the setting (3.2) and controlled for the weights of the Bartik instrumental variables and $(\sum_{d \neq i} \omega_{ijd,t=0})$ to avoid potential errors (Borusyak et al., 2022). $\ln(sales)_{ijt}$ is the "e-commerce index" defined in the previous section, i.e., the sales on the e-commerce platform of the sampled districts and counties of Jindong's e-commerce transaction data (logarithmically), which is used to reflect the active participation of local enterprises in e-commerce in this paper. Although Jingdong is leading the competition in China's e-commerce market, it does not hold the vast majority of the market share, so the text uses Jindong's data and set analysis results that may underestimate the actual effect. The regressions control for socioeconomic development indicators such as GDP per capita, population density, urbanization rate, fiscal self-sufficiency, fixed asset investment, and regional area in the previous year as control variables, and also control for district-industry two-way fixed effects and quarterly fixed effects.

The second stage of the Bartik instrumental variable regression was set as follows.

$$Y_{ijt} = \beta_1 \times \ln(\widehat{\text{Sales}})_{ijt} + \beta' \mathbf{X}_{it-4} + FEs + \varepsilon_{ijt} \quad (4.2)$$

where Y_{ijt} denotes the outcome variable for industry j in district i at quarter t (taking logarithms for continuous variables), the control variables and fixed effects are set as in (3.1), and the standard deviations of the regressions are clustered to the district and county level. When the explanatory variables are taken in logarithmic form, the estimated value of the regression coefficient β_1 represents the size of the elasticity of the effect of e-commerce

expansion on the outcome variable.

In the test section of spillover effects and potential channels, this chapter focuses on the dummy variables of operator's gender, whether it is an e-commerce operator and its interaction term to reflect the channels of e-commerce influence on female entrepreneurship, and the spillover effects of female entrepreneurship. The specific settings are as follows.

$$Y_i = \beta_1 \times (\text{Female} \times \text{Ecom})_i + \beta_2 \times \text{Female}_i + \beta_3 \times \text{Ecom}_i + \mathbf{x}_i' \theta + \text{FEs} + \varepsilon_i \quad (4.3)$$

Where Female_i is a dummy variable for female operators and Ecom_i is a dummy variable for e-commerce operators, the coefficient β can describe the difference between different types (gender, e-commerce adoption) of operators on the indicator Y_i . Control variables include firm age, operator age, registration type (corporate, registered individual business, unregistered individual business), full-time employee size, and quarterly business revenue. For multi-quarter mixed cross-sectional data, the regressions control for city, industry, quarter fixed effects, corresponding two-way fixed effects, and three-way fixed effects. For single-quarter cross-sectional data, they control for city, industry fixed effects, and two-way fixed effects. The standard deviations of the regressions are clustered to the city level.

3.2 Empirical Results

Table 1 shows the baseline regression results on the impact of demand expansion on the Jingdong e-commerce platform on female entrepreneurship within the sample districts and counties. Column (1) examines the effect on the expansion margin (extensive margin) and finds that the demand shock of e-commerce expansion does not promote female entrepreneurs to enter into local industries where no women were previously involved. In columns (2) and (3), we further examine the number and proportion of female entrepreneurs at the intensive margin and find that the demand shock of e-commerce expansion significantly increases the number of female entrepreneurs among new firms, with an estimated elasticity of nearly 0.678 with respect to sales growth on the Jingdong e-commerce platform. At the same time, the proportion of women among the legal representatives of new entrants also increases significantly. According to the calculation, the number of new entrants in the relevant industries in the sample districts and counties increased by 12.8% between 2015 and 2019, of which the number of enterprises with women as legal representatives increased by nearly 17.8%. If calculated based on the average growth rate of sales on the Jingdong e-commerce platform of 25.4% during the period, the impact of e-commerce expansion can explain the higher percentage of growth in the number of female entrepreneurs. In addition,

the proportion of female legal representatives increased from 25.1% to 26.7% during the period, while the contribution of e-commerce expansion reached 0.9 percentage points based on the estimated value of the coefficient in column (3), again explaining nearly 56.3% of the increase in the proportion of women.

[Table 1 Here]

Table 2 reports the impact of e-commerce expansion on the employment of female executives (non-statutory representatives) in new businesses in positions such as supervisor, director (chairman, executive director), general manager, director and manager, (vice) chairman, executive director, (vice) general manager, and head. The results in column (1) show that districts and industries that are more impacted by the demand for purchases on the Jingdong e-commerce platform have more women serving as executives in new businesses. The regression results in column (1) for female legal representatives reveal that the development of e-commerce has led to more women participating in business management, but has not significantly contributed to women’s own entrepreneurial behavior, which on the one hand reflects that digital technologies such as e-commerce can play a role in empowering women and narrowing the gender gap in career development, but on the other hand may also reflect that women still face strong external constraints such as financial disincentives, so that even if digital technologies such as e-commerce can facilitate women’s participation in the labor market, it is still difficult for women to start their own businesses. Second, the results in columns (2) and (3) also show that both the number and proportion of female executives in new firms have been significantly increased by the impact of e-commerce expansion.

[Table 2 Here]

Based on the “business scope” field of registered businesses, we can identify not only newly established but also existing e-commerce related firms. We then examine the heterogeneity of the impact of e-commerce expansion on female entrepreneurs. The corresponding results are reported in two panels of Table 3. Panel A shows that the demand expansion shock of e-commerce platforms significantly facilitates women’s creation of businesses involved in e-commerce, both at the expansion margin and the intensification margin. This finding suggests that female potential entrepreneurs who are influenced by the digital economy, such as e-commerce, are more likely to choose industries or business models that are

relevant to their entrepreneurial activities. In contrast, Panel B reports that female entrepreneurial activity in the "non-e-commerce category" is not significant. The estimates in column (2) of Panel B show a significant increase in the proportion of female entrepreneurs in "non-e-commerce" start-ups, but column (3) shows a significant increase in overall female entrepreneurial activity. However, column (3) shows that there is no significant increase in the proportion of women overall. The reason for this result is that the dataset used in this paper is based on Jingdong e-commerce transaction data with product categories matched to corresponding industries (see Data Construction), so the increase in sales will naturally promote the entry of more companies in the corresponding local industries.

[Table 3 Here]

Similarly, this paper also finds that e-commerce expansion increases the proportion of female executives among newly established firms using e-commerce operations, as shown in Table 4. Panel A shows, at the same time, that the proportion of female executives in new firms that are affected by e-commerce expansion increases significantly regardless of whether they are identified by this paper's business scope text analysis algorithm as engaging in e-commerce-related business activities.

[Table 4 Here]

3.3 Spillover Effect

There is also a positive spillover effect of the expansion of e-commerce on the employment participation of female employees. Studies have found a "same-sex preference" for female entrepreneurs and a higher probability of team formation among women (Gompers et al., 2017). Graeber et al. (2021) has also been noted that female micro and small operators were more severely affected during the Covid-19 restrictions, in part because female-concentrated industries were hit harder. Female CEOs also hired more female employees (Navarro and Gallo, 2014). The wage gap between male and female employees also reduced (La Mattina et al., 2018). On the one hand, female entrepreneurship may be more concentrated in female labor-intensive industries to make better use of the knowledge, skills, and channels accumulated on the job. On the other hand, women may be hired for reasons such as same-sex preference and altruistic preference. Since the business enterprise registration dataset do not contain information on the composition of employees, this paper uses OSOME for descriptive analysis.

Figure 5 shows the distribution of the proportion of female entrepreneurs and the proportion of female employees at the city-industry level summed for micro and small operators involved in e-commerce (online sales) and non-e-commerce micro and small operators, respectively, and distinguishes the three broad industry categories with different colored bubbles. Among them, participation in e-commerce was distinguished according to whether the proportion of their online sales in the questionnaire was greater than zero. The proportion of female employees was significantly and positively correlated with the proportion of female operators in both categories of micro and small operators. Second, in the comparison between different industries, both female operators and female employees are more concentrated in the service industry; while within the three major categories of industries, the positive correlation between female employees and female operators still exists. This result may, to some extent, corroborate the two potential mechanisms mentioned above, i.e., female entrepreneurs are more likely to start businesses in industries with a relatively high concentration of female labor, while female-owned firms within the industry also employ more women. More importantly, a comparison of the sample of e-commerce operators with the sample of non-e-commerce operators reveals that female operators engaged in e-commerce employ a higher proportion of female full-time employees, and this trend remains evident across broad industry categories and when the proportion of female operators is given. Combined with the findings in the previous section, the expansion of e-commerce can not only promote more women to start and engage in e-commerce types of business activities, thus narrowing the gender gap in entrepreneurship, but also further narrow the gender gap in the overall job market by employing more women full-time employees.

[Figure 5 Here]

To avoid the impact of Covid-19 starting in 2020 and the preventive and control measures on operators' adoption of e-commerce, this paper limits the sample to small and micro enterprises established in 2019 and before, and excludes enterprises with localized outbreaks in their cities at the time of the interview. Also, as a robustness check, the paper selects online store sellers registered on the Taobao platform as a subsample of e-commerce operators for further analysis. The results are shown in Figure 6. The basic trend remains robust. Second, it is also found that the proportional distribution of female operators and female employees among Taobao registered sellers in the construction and processing manufacturing industry is similar to that of Taobao registered sellers in the service industry. That is, small and medium-sized enterprises registered as agriculture, forestry, animal husbandry and

fishery, processing, and manufacturing also carry out sales-type business activities, including the registration of online stores in e-commerce platforms for sales. Meanwhile, among the small and micro-operators in the construction and processing manufacturing industries, the proportion of female operators and employees of Taobao-registered sellers is higher than that of non-Taobao-registered sellers, which is also consistent with the finding that e-commerce has promoted female entrepreneurship and employment in the previous section.

[Figure 6 Here]

Table 5 further reports descriptive results using regression analysis at the individual level, controlling for variables such as firm age, operator age, type of business, and quarterly operating income, as well as city, industry, quarterly fixed effects, two-way fixed effects, and city-industry-quarterly fixed effects. The results in column (1) show that among non-Taobao e-commerce operators, the average employee size of female-owned firms is lower than that of males, possibly related to the fact that women start more businesses in the informal sector. The average employee size of Taobao registered merchants is also lower, which is somewhat consistent with the previous finding that e-commerce reduces the size of new businesses. Meanwhile, female Taobao sellers have the lowest average number of employees, with a coefficient estimate of about -0.868 ($=0.352-0.462-0.758$). Column (2), on the other hand, shows that female operators hire more female employees, while female-run Taobao sellers also employ significantly more women compared to male-run Taobao sellers (coefficient estimate of about $0.121 = 0.205 + 0.132 - 0.216$). Based on this, in terms of the proportion of female employees (column (3)), female operators are significantly higher, especially those who are engaged in e-commerce in Taobao. The above estimation results suggest that e-commerce not only promotes female entrepreneurial activities, but also enables more female employees to be employed in it, which in turn reduces the gender gap in both the entrepreneurial and employment markets.

[Table 5 Here]

In addition, the questionnaire from the fourth quarter of 2020 includes a question on "whether or not to pay social security for full-time employees." Using a similar analysis (as shown in Figure 4.7), it is found that, on average, Taobao registered sellers have a higher percentage of full-time employees who pay social security, and there is a positive correlation with the percentage of female entrepreneurs. This result suggests, to some extent, that the

spillover effect of e-commerce on female employment not only increases the size and share of female employees at the extended margin, but also increases the overall welfare protection of employees at the intensive margin.

[Figure 7 Here]

4 Channels

In this subsection, this chapter will use a descriptive analysis to examine potential channels through which e-commerce promotes female entrepreneurship, particularly by engaging in e-commerce related business activities. First, e-commerce may promote female entrepreneurship by lowering the capital barriers to female entrepreneurship. The third chapter of this paper finds that the demand expansion of e-commerce lowers the capital barrier to entry for new businesses. The reason for this is that, on the one hand, the demand expansion of e-commerce also increases the diversity of demand, which to some extent weakens the scale effect brought by the expansion of business. On the other hand, based on China's vigorous promotion of network, logistics, and other infrastructure facilities, the cost of e-commerce enterprises in terms of store rent, personnel employment, and multi-level distributors is lower than that of enterprises operating offline sales. And it has been found that women usually face financial constraints in the process of starting a business (Verheul and Thurik, 2001; Sauer and Wilson, 2016). Therefore, women are more likely to enter the informal sector with relatively low capital requirements on the one hand, and can use e-commerce to lower the entry barrier on the other.

The operators' registered capital size was not directly asked in the Chinese micro and small operators questionnaire, but the Figure 4.8 results in this paper indicate that the size of female e-commerce operators, measured by the number of full-time employees, is significantly lower than that of female non-e-commerce operators (although the cross-term estimate is positive, the total effect estimate is $= 0.352 - 0.462 - 0.758 = -0.868$). In addition, this paper also uses baseline survey data from the Survey of Enterprise Innovation and Entrepreneurship in China (ESIEC) and matches the sample's registered capital information in the business enterprise registration data for descriptive tests. Figure 4 .8 shows the lower 5% quantile level trend of the proportion of enterprises selling online summed at the city-industry level versus registered capital is first shown, and distinguishes between female and male operators, showing that the threshold of registered capital among female operators tends to decrease

as the proportion of e-commerce adoption increases. There is no significant trend among the sample of male operators.

[Figure 8 Here]

In Figure 9 using the median level of registered capital as a robustness test, it is also found that the median level of registered capital is negatively correlated with the percentage of their online sales for female-run businesses, while it is not significant for male-run businesses. More importantly, since the e-commerce model breaks the spatial distance limit, it faces a larger market size, and thus the expected return of engaging in e-commerce may be higher for a given scale of operation. This may be one of the potential motivations for female entrepreneurs to choose to engage in e-commerce types of business activities. Of course, competition on e-commerce platforms may also be more intense, which in turn reduces expected returns. However, for female entrepreneurs operating more in the informal sector, they face equally fierce competition in the offline market, which is relatively limited in size.

[Figure 9 Here]

Secondly, another advantage of engaging in e-commerce for women is the flexibility of time use. It has been noted that women value flexibility in their career choices, such as a preference for part-time work (Booth and Van Ours, 2008, 2013), and Le Barbanchon et al. (2021) and (Meekes and Hassink, 2022) also found that post-employment women's preference for job flexibility led to shorter work hours and commuting distances in their new jobs. shorter hours and commuting distances. One reason for the continuing decline in female labor force participation in China is the need for women to take greater care of their families (Ke et al., 2012). The report also notes that the proportion of "full-time mothers" in China continues to rise .²¹ One of the characteristics of e-commerce is the greater flexibility in terms of workplace and time. In terms of workplace, e-commerce practitioners can complete the work of product launch, sales, customer service, and product delivery in factories or warehouses, or even complete most of the work at home, which not only saves commuting time, but also allows them to take care of their families. The Internet (especially mobile Internet) has also broken the traditional time limit of sales, so that practitioners can

²¹According to Baby Tree's "2019 White Paper on Chinese Families' Pregnancy and Parenting Styles," the proportion of full-time mothers among the "post-95" population exceeds 80%, but its statistics include those who work full-time at home to care for their children but are preparing to find a job. For details, please see: <http://news.cctv.com/2019/12/25/ARTI51mwbGBCaTL5s1tL7k2m191225.shtml>

complete the related work at any time and with ease. For this reason, e-commerce can help women combine family care and work at the same time, making it more attractive to women who have entrepreneurial potential but are constrained by family commitments.

Based on this, this paper uses the OSOME data in the first quarter of 2022, which includes module on family care and subjective attitude. After excluding the sample of micro and small operators established after 2019 and the sample of cities hit by the Covid-19 pandemic in the first quarter of 2022, a total of 4,918 questionnaires with special questions were collected in this survey. Figure 10 shows the average weekly time (hours/week, including 5 working days and 2 weekends) spent by micro and small operators on running their business. Dealing with family affairs is shown separately by whether they are registered Taobao sellers and the gender of the operator. In terms of running a business, the time invested by men is significantly higher than that of women, especially among registered Taobao sellers, where the difference between women and men in terms of operating time is more obvious. In terms of handling household chores, on average, women devoted more time, but there was no significant difference at the 95% significance level, and the difference was more pronounced among Taobao registered sellers.

[Figure 10 Here]

Since the comparison of unconditional means may be confounded by other factors, this paper further controls for operator and merchant level characteristics (age of the firm, age of the operator, type of business, size of full-time employees, quarterly operating income, etc.) as well as city and industry level fixed effects and two-way fixed effects for the regression analysis. Table 6 contains descriptive results, where columns (1)-(2) use the valid sample recovered for this topic and find, consistent with Figure 10, and consistent with the fact that women devote less time to business, more time to household chores, and more importantly, female operators engaged in Taobao merchant operations significantly devote more time to household matters, an increase of about 30.7% compared to the mean level. This result suggests that e-commerce allows female operators to be more flexible in balancing business and household tasks. In columns (3) and (4), the sample is further restricted to married micro and small operators and the results are found to be still robust and the coefficient estimates of the cross-sectional term are larger. Thus, the temporal flexibility of e-commerce is also an important mechanism for its promotion of female entrepreneurship and greater engagement in e-commerce operations.

[Table 6 Here]

Finally, this paper also examines the most important difficulties that female Taobao sellers face in digital transformation or upgrading, such as e-commerce. The OSOME adds the question "What are the most important difficulties you encountered in using digital means to run your business or in the process of digital and electronic transformation" to the questionnaire in the second quarter of 2021 (up to two choices). In line with the previous section, the sample was limited to micro and small operators established in 2019 and earlier, and operators in cities with local outbreaks in the current quarter were excluded to avoid the impact of the coronary pneumonia Covid-19 pandemic. The results are shown in Table 7. External factors (especially high usage costs and weak infrastructure hardware) are the main difficulties for female non-e-commerce operators, as well as greater concern about the risks associated with e-commerce and other digital transformations. Female e-commerce operators, on the other hand, were most concerned about the cost of digital transformation or upgrade among external factors, but less concerned about the difficulties posed by basic hardware, reflecting to some extent that the lower hardware threshold for e-commerce is more favorable for women who are at a disadvantage in terms of digital technology acquisition. at the same time, female e-commerce operators also reported that they lacked sufficient time and energy to further learn how to use it, indicating that family care and e-commerce business have taken up most of their time and energy.

[Table 7 Here]

4.1 Women's Resilience Throughout the COVID-19 Pandemic

By merging the OSOME data with data on the outbreaks of Covid-19 and resultant local mitigation policies, we further examine how e-commerce and other digital technologies helped female entrepreneurs. Taking the sporadic COVID cases and lockdowns in local areas as exogenous shocks to SMEs, we adopt the following difference-in-differences method for female- and male-owned SMEs respectively.

$$Y_{ijt} = \beta \times (\text{COVID} \times \text{After})_{cyq} + x_i\theta + FE_S + \epsilon_{ijcq}, \quad (2)$$

where the subscript indicates that micro and small operators i in industry j in city c were surveyed in quarter q of year y . The core explanatory variable is $(\text{COVID} \times \text{After})_{cyq}$, which takes the value of 1 when the city where the surveyed micro and small operators are located has experienced an outbreaks and lockdown, and 0 otherwise. Control variables include the

time of business establishment (age of business), type of registration (corporate business, registered individual business, unregistered individual), full-time employee size, quarterly business revenue, and operator’s age. ordinary linear regressions (OLS) also control for city, industry, and quarterly fixed effects, as well as two-way city-industry, city-year, and industry-year fixed effects; the standard deviations of the regressions are clustered to the city level. The results of the regressions using the fixed effects logit model remain robust.

In Table 8, the regression analysis with online operations and online sales as outcome variables is first reported. The explanatory variable in column (1) is a dummy variable for whether the micro and small operators operate online, as opposed to operating offline only. In the questionnaire, "offline" refers to having a physical production or business location, store, or in-person communication, while "online" refers to conducting all or most of their economic activities online. Columns (2) and (3) are refined to both online and offline operations, and online operations only (such as pure e-commerce operations). The explanatory variables in columns (4) and (5) are dummy variables for whether sales are conducted online, and whether marketing is conducted online (e.g., short videos, live streaming, etc.), respectively. As shown in Panel A, localized sporadic outbreaks and blockades significantly increase the proportion of female micro and small operators who adopt online operations and online sales. Specifically, compared to the average percentage of micro and small business female operators who operated online (44.5%), the percentage of women who operated online increased by 17.1% in the post-local sporadic outbreak and restriction period, especially for the online-only model, which increased by about 27.2% compared to the average, and for the combined online and offline model, which increased by 13.6% compared to the average. This finding suggests that Chinese female micro and small operators are making better use of online operations to improve their operations. Also, the results in column (4) show that female micro and small operators are more likely to adopt online sales after localized Covid-19 pandemics and restrictions, indicating that digital technologies such as e-commerce significantly empower female entrepreneurship and operations. In addition, the results in column (5) indicate that women are also more likely to adopt online marketing tools such as short videos and live-streaming with goods, which is about 18.9% higher compared to the mean level. In contrast, the results of the regression analysis of the sample of male micro and small operators in Panel B show that the coefficient estimates are small and insignificant for both all forms of online operations and selling online (including mobile Internet), indicating that male micro and small operators did not adopt more online operations or sales after the local Covid-19 pandemic and embargo. Comparing the results for female and male micro and small

operators reveals that the two groups are relatively close in the means of the explained variables, but in response to localized sporadic outbreaks and restriction measures, females significantly adopt more e-commerce and online operations to cope with them compared to males, reflecting not only the resilience of females in the face of business crises, but also the empowering effect of digital technologies such as e-commerce on females.

[Table 8 Here]

Table 9 shows more results. The effects of local outbreak and blockade on female and male micro and small operators in terms of introducing telecommuting and electronic information systems were examined using the same settings. The results in column (1) show that both female and male micro and small operators adopted telecommuting (or business) mode more after the local outbreak and blockade, with an increase of about 30.9% and 16.4%, respectively, relative to the mean level, i.e., female micro and small operators had a higher increase in telecommuting after the shock. In addition, in terms of the introduction of electronic information systems, female micro and small operators also significantly introduced more sales-type systems, with an increase of 20.0% compared to the average level, which is also consistent with the increased adoption of online business and online sales by women after the impact. For other types of e-information systems, this paper did not find that either female or male micro and small operators introduced more after the local Covid-19 pandemic outbreak and restrictions. For the introduction of telecommuting and sales-type e-information systems, the digital transformation of female micro and small operators was more rapid than that of males, suggesting that digital technology has improved women’s entrepreneurial capacity and resilience to cope with difficulties.

[Table 9 Here]

5 Conclusion

By combining administrative business registration data, Jingdong e-commerce transaction data, online surveys, and offline surveys, this paper shows that the expansion of e-commerce has promoted female entrepreneurship and further increased female employee employment. The lower capital and infrastructure thresholds for e-commerce and the time flexibility are potentially important reasons for the high take up of women entrepreneurs in

the e-commerce sector. Moreover, women entrepreneurs significantly increased their adoption of e-commerce and online operations in response to the Covid-19 shock, reflecting the role of digital technologies such as e-commerce in enhancing their resilience.

Innovatively, this paper uses a Bayesian method to predict the gender of entrepreneurs by their Chinese names. Combined with the text analysis algorithm for identifying e-commerce enterprises, we show that female entrepreneurs and executives are concentrated in e-commerce enterprises, and their growth trend is in line with the development of e-commerce. This paper further matches the Jingdong e-commerce transaction data and uses the demand shock of e-commerce expansion to construct Bartik instrumental variables for causal identification, confirming our hypothesis that the expansion of e-commerce in China has promoted the entrepreneurial behavior of female entrepreneurs.

Further, using online and offline survey data, we find that women-owned e-commerce businesses hire more female employees and have a higher proportion of female full-time employees. Thus, e-commerce not only directly promotes female entrepreneurship, but also promotes more female employment and reduces the gender gap in employment.

Finally, the results estimated using OSOME survey data in combination with information on local Covid-19 outbreaks show that female micro and small operators after the outbreak adapted significantly faster to e-commerce and other digital transformations than men, indicating that digital technologies such as e-commerce also improved female operators' resilience in coping with shocks.

The development of women's entrepreneurial talents can also help reduce the discrimination against women and talent misallocations, thus improving the overall economic efficiency. Especially in the context of the digital economy, a better utilization of the female workforce would be beneficial for sustainable economic growth and innovation in the long run. The findings in this paper also have some practical implications. First, the expansion of market size and rapid economic growth brought about by e-commerce can synergize with improvements in gender equality issues. Second, while there are some criticisms on platform monopolies, this paper provides empirical evidence that technological changes in the digital economy have improved the situation of disadvantaged groups in society, suggesting that the digital economy does not necessarily imply monopolies and inequality.

It is worth noting that the findings may be China specific. The development of e-commerce in China has benefited from the long-term large-scale construction of infrastructural facilities, such as systems for Internet services, transportation, and warehousing and logistics. E-commerce may be more difficult to scale up in some other developing coun-

tries where basic infrastructure is lacking. In addition, this paper focuses on the role of e-commerce, while other forms of digital technology may also promote female entrepreneurship or help women to be treated more equally in other ways. Thus, the findings in this paper may underestimate the true effect of digital technology change on female empowerment.

There are still research gaps in our study. This paper does not emphasize the role of education due to lack of data, but entrepreneurial talent cannot be developed without the influence of education and personal experience, especially since the use of digital technologies also depends on the availability of education. And at the same time, the guarantee of women's right to education has always been an important issue of concern for the international community. Therefore, rethinking women's digital entrepreneurship from the perspective of women's access to education is more far-reaching.

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Appendix

Tables

Table 1: Impact of E-Commerce Expansion on Female Entrepreneurship

	(1)	(2)	(3)
	Entrepreneurs (legal representatives) of Newly Established Enterprises Is There a Female	Number of Women (log)	Percentage of Women
E-Commerce Index	-0.008 (0.031)	0.678*** (0.185)	0.038** (0.017)
Control Variables	Yes	Yes	Yes
District and County Fixed Effects	Yes	Yes	Yes
Industry Fixed Effects	Yes	Yes	Yes
District-Industry Fixed Effects	Yes	Yes	Yes
Quarterly Fixed Effects	Yes	Yes	Yes
Observations	74,052	22,062	22,062
Adj. R-sq	0.001	-2.562	0.231

Note: Results in the table are estimated using two-stage regressions of Bartik instrumental variables. Standard errors of clustering to the district and county level are reported in parentheses. The explanatory variable "e-commerce index" is the sales on the Jingdong platform in the sample counties (logarithmically). The explanatory variables are the dummy variable for female entrepreneurs (defined as legal representatives) in new enterprises, the number (in logarithm), and the proportion, respectively. The control variables include GDP per capita, population density, urbanization rate, financial self-sufficiency rate, fixed asset investment, and regional area. The regressions also control for district, industry, and quarter fixed effects as well as district-industry two-way fixed effects. Significance levels: * $p < 0.1$ ** $p < 0.05$ *** $p < 0.01$

Data source: Jingdong e-commerce transaction data, China business registration data.

Table 2: Impact of E-Commerce Expansion on Female Executive Tenure

	(1) Executives (non-legal representatives) of Newly Established Enterprises Availability of Female Executives	(2) Number of Female Executives (log)	(3) Percentage of Female Executives
E-Commerce Index	0.115 (0.067)	0.429*** (0.126)	0.048** (0.018)
Control Variables	Yes	Yes	Yes
District and County Fixed Effects	Yes	Yes	Yes
Industry Fixed Effects	Yes	Yes	Yes
District-Industry Fixed Effects	Yes	Yes	Yes
Quarterly Fixed Effects	Yes	Yes	Yes
Observations	74,052	38,119	38,119
Adj. R-sq	0.109	-1.042	0.057

Note: Results in the table are estimated using two-stage regressions of Bartik instrumental variables. Standard errors of clustering to the district and county level are reported in parentheses. The explanatory variable "e-commerce index" is the sales on the Jingdong platform in the sample counties (logarithmically). The explanatory variables are the dummy variable for female executives (non-statutory representatives) in new enterprises, the number (in logarithm), and the proportion, respectively. The control variables include GDP per capita, population density, urbanization rate, financial self-sufficiency rate, fixed asset investment, and regional area. The regressions also control for district, industry, quarterly fixed effects, and district-industry two-way fixed effects. Significance levels: * $p < 0.1$ ** $p < 0.05$ *** $p < 0.01$

Data source: Jingdong e-commerce transaction data, China business registration data.

Table 3: Impact of E-Commerce Expansion on Female Entrepreneurship in E-Commerce Related New Businesses

	(1) Entrepreneurs (legal representatives) of Newly Is There a Female	(2) Number of Women (log)	(3) Established Enterprises Percentage of Women
Panel A: E-Commerce Related Businesses			
E-Commerce Index	0.031*** (0.010)	0.117*** (0.047)	0.032*** (0.012)
Adj. R-sq	0.066	0.261	0.471
Panel B: Non-E-Commerce Related Companies			
E-Commerce Index	-0.009 (0.031)	0.332*** (0.125)	0.490 (0.355)
Adj. R-sq	0.001	0.436	0.128
Control Variables	Yes	Yes	Yes
District and County Fixed Effects	Yes	Yes	Yes
Industry Fixed Effects	Yes	Yes	Yes
District-Industry Fixed Effects	Yes	Yes	Yes
Quarterly Fixed Effects	Yes	Yes	Yes
Observations	74,052	22,062	22,062

Note: Results in the table are estimated using two-stage regressions of Bartik instrumental variables. Standard errors of clustering to the district and county level are reported in parentheses. The explanatory variable "e-commerce index" is the sales on the Jingdong platform in the sample counties (logarithmically). The explanatory variables are the dummy variables for female entrepreneurs (defined as legal representatives) in new enterprises, the number (in logarithm), and the proportion, respectively. The control variables include GDP per capita, population density, urbanization rate, financial self-sufficiency rate, fixed asset investment, and regional area. The regressions also control for district, industry, and quarter fixed effects as well as district-industry two-way fixed effects. "E-commerce" firms were distinguished from "non-e-commerce" firms by the text analysis method described previously using the business scope text. Significance levels: $*p < 0.1$ $**p < 0.05$ $***p < 0.01$ Data source: Jingdong e-commerce transaction data, China business registration data.

Table 4: Impact of E-Commerce Expansion on Female Executive Representation in E-Commerce Related New Businesses

	(1) Executives (non-legal representatives) of Newly Established Enterprises Availability of Female Executives	(2) Number of Female Executives (log)	(3) Percentage of Female Executives
Panel A: E-Commerce Related Businesses			
E-Commerce Index	0.014 (0.010)	0.056* (0.031)	0.012* (0.007)
Adj. R-sq	0.071	0.079	0.052
Panel B: Non-E-Commerce Related Companies			
E-Commerce Index	0.019 (0.033)	0.204*** (0.075)	0.267 (0.198)
Adj. R-sq	0.005	0.225	0.040
Control Variables	Yes	Yes	Yes
District and County Fixed Effects	Yes	Yes	Yes
Industry Fixed Effects	Yes	Yes	Yes
District-Industry Fixed Effects	Yes	Yes	Yes
Quarterly Fixed Effects	Yes	Yes	Yes
Observations	74,052	38,119	38,119

Note: Results in the table are estimated using two-stage regressions of Bartik instrumental variables. Standard errors of clustering to the district and county level are reported in parentheses. The explanatory variable "e-commerce index" is the sales on the Jingdong platform in the sample counties (logarithmically). The explanatory variables are the dummy variables for female entrepreneurs (defined as legal representatives) in new enterprises, the number (in logarithm), and the proportion, respectively. The control variables include GDP per capita, population density, urbanization rate, financial self-sufficiency rate, fixed asset investment, and regional area. The regressions also control for district, industry, and quarter fixed effects as well as district-industry two-way fixed effects. "E-commerce" firms were distinguished from "non-e-commerce" firms by the text analysis method described previously using the business scope text. Significance levels: $*p < 0.1$ $**p < 0.05$ $***p < 0.01$

Data source: Jingdong e-commerce transaction data, China business registration data.

Table 5: Employees of Female Micro and Small Operators, Taobao Sellers and the Proportion

	(1) Number of Employees	(2) Number of Female Employees	(3) Percentage of Female Employees
Female Operators x Taobao Sellers	0.352* (0.198)	0.205* (0.121)	0.033** (0.014)
Female Operators	-0.462*** (0.051)	0.132*** (0.029)	0.120*** (0.004)
Taobao Sellers	-0.758*** (.109)	-0.216 (0.065)	0.000 (0.006)
Adj. R-sq	0.150	0.071	0.039
Control Variables	Yes	Yes	Yes
Quarterly, City, and Industry Fixed Effects	Yes	Yes	Yes
Two-Way Fixed Effects	Yes	Yes	Yes
Quarterly-City-Industry Fixed Effects	Yes	Yes	Yes
Observations			63,568

Note: All regression results reported in the table use OLS estimates. Standard errors for clustering to the city level are reported in parentheses. Control variables include firm age, operator age, type of business, and quarterly operating income. Regressions also control for city, industry, and quarterly fixed effects, as well as two-way fixed effects, and city-industry-quarter fixed effects. The sample is limited to micro and small operators established before 2020 and excludes operators in cities with a local Covid outbreak at the time of the survey. Levels of significance: * $p < 0.1$ ** $p < 0.05$ *** $p < 0.01$

Data source: Online survey of small-and-micro enterprises in China (OSOME).

Table 6: Business and Family Care Time Commitment of Female Micro-Operators and Taobao Sellers

	(1)	(2)	(3)	(4)
	Full Sample of Topics		Married Sample	
	Operation	Housekeeping	Operation	Housekeeping
Female Operators x Taobao Sellers	2.940 (5.947)	8.584* (4.362)	3.491 (7.135)	9.644* (5.476)
Female Operators	-8.888*** (1.344)	3.005*** (1.023)	-8.112*** (1.596)	3.159*** (1.156)
Taobao Sellers	-0.928 (2.491)	-0.036 (1.814)	-2.897 (3.042)	-2.219 (1.999)
Adj. R-sq	0.063	0.009	0.052	0.005
Control Variables	Yes	Yes	Yes	Yes
Quarterly, City, and Industry Fixed Effects	Yes	Yes	Yes	Yes
Two-Way Fixed Effects	Yes	Yes	Yes	Yes
Quarterly-City-Industry Fixed Effects	Yes	Yes	Yes	Yes
Observations		4,918	3,410	

Note: All regression results reported in the table use OLS estimates. Standard errors for clustering to the city level are reported in parentheses. Control variables include firm age, operator age, type of business, employee size, and quarterly operating income. Regressions control for city and industry fixed effects, as well as city-industry two-way fixed effects. Only valid samples collected from the "female micro and small operators" topic in the first quarter of 2022 are used, while limiting to micro and small operators established before 2020 and excluding those in cities with Covid outbreaks in that quarter. Significance level: * $p < 0.1$ ** $p < 0.05$ *** $p < 0.01$

Data source: OSOME.

Table 7: Top Difficulties of Female Micro and Small Operators in Digital Transformation or Upgrading

	(1)	(2)	(3)	(4)
	The Most Important Difficulties Encountered in Digital Transformations or Upgrading Such as E-Commerce			
Panel A: Subjective Factors	Subjective Factors	No Time and Energy	Will Not Use	Fear of Risk
Female Operators x Taobao Sellers	0.077 (0.063)	0.118** (0.058)	-0.030 (0.045)	0.060 (0.055)
Female Operators	-0.021 (0.015)	-0.073*** (0.014)	-0.011 (0.011)	0.059*** (0.012)
Taobao Sellers	-0.018 (0.025)	-0.010 (0.023)	0.007 (0.023)	-0.028* (0.017)
Adj. R-sq	0.016	0.032	0.020	0.009
Panel B: External Factors	External Factors	Higher Cost	Shortage of Funds	Weak Basic Hardware
Female Operators x Taobao Sellers	-0.013 (0.052)	-0.006 (0.058)	0.067 (0.048)	-0.063*** (0.020)
Female Operators	0.053*** (0.013)	0.058*** (0.058)	0.004 (0.048)	0.014* (0.020)
Taobao Sellers	0.053*** (0.023)	0.058*** (0.022)	0.004 (0.019)	0.014* (0.012)
Adj. R-sq	0.049	0.021	0.030	0.006
Control Variables	Yes	Yes	Yes	Yes
Urban Fixed Effects	Yes	Yes	Yes	Yes
Industry Fixed Effects	Yes	Yes	Yes	Yes
City-Industry Fixed Effects	Yes	Yes	Yes	Yes
Observations			8,873	

Note: All regression results reported in the table use OLS estimation, and consistent results are obtained under the Logit model. Standard errors for clustering to the city level are reported in parentheses. Control variables include firm age, operator age, type of operation, employee size, and quarterly operating income. Regressions also control for city and industry fixed effects, as well as city-industry two-way fixed effects. Using data for the second quarter of 2021 only, the sample is limited to micro and small operators established before 2020 and excludes samples from cities with Covid outbreaks at the time of the interview. Levels of significance: * $p < 0.1$ ** $p < 0.05$ *** $p < 0.01$ Data source: OSOME.

Table 8: Impact of Local Outbreak and Prevention and Control Measures on Online Operations and Sales of Micro and Small Operators, by Gender

	(1)	(2)	(3)	(4)	(5)
	Any Form	Online Business Combination of Online and Offline	Online Only	Online Sales	Online Marketing
Panel A: Female Operators					
COVID x After	0.076*** (0.027)	0.045* (0.024)	0.031* (0.016)	0.073*** (0.024)	0.046** (0.021)
Mean Value of Dependent Variable	0.445	0.331	0.114	0.393	0.243
Standard Deviation of Dependent Variable	0.497	0.471	0.317	0.488	0.429
Adj. R-sq	0.010	0.003	0.050	0.024	-0.016
Observations			14,587		
Panel B: Male Operators					
COVID x After	0.009 (0.012)	0.006 (0.013)	0.003 (0.007)	0.002 (0.011)	-0.003 (0.010)
Mean Value of Dependent Variable	0.440	0.331	0.109	0.381	0.214
Standard Deviation of Dependent Variable	0.496	0.471	0.311	0.486	0.410
Adj. R-sq	0.058	0.044	0.064	0.066	0.040
Observations			69,729		
Control Variables	Yes	Yes	Yes	Yes	Yes
Quarterly Fixed Effects	Yes	Yes	Yes	Yes	Yes
Urban Fixed Effects	Yes	Yes	Yes	Yes	Yes
Industry Fixed Effects	Yes	Yes	Yes	Yes	Yes
City-Industry Fixed Effects	Yes	Yes	Yes	Yes	Yes
City-Annual Fixed Effects	Yes	Yes	Yes	Yes	Yes
Industry-Annual Fixed Effects	Yes	Yes	Yes	Yes	Yes

Note: All regression results reported in the table use OLS estimation, and consistent results are obtained under the Logit model. Standard errors for clustering to the city level are reported in parentheses. COVID $\times$ After takes the value of 1 after the city where the micro and small operator is located is subject to a localized outbreak of Covid-19 and preventive and control measures such as a lockdown, and 0 otherwise. control variables include firm age, operator age, type of operation, employee size, and quarterly operating income. The regressions also controlled for city, industry, and quarterly fixed effects, as well as city-industry, city-year, and industry-year bivariate fixed effects. Significance levels: * $p < 0.1$ ** $p < 0.05$ *** $p < 0.01$

Data source: OSOME.

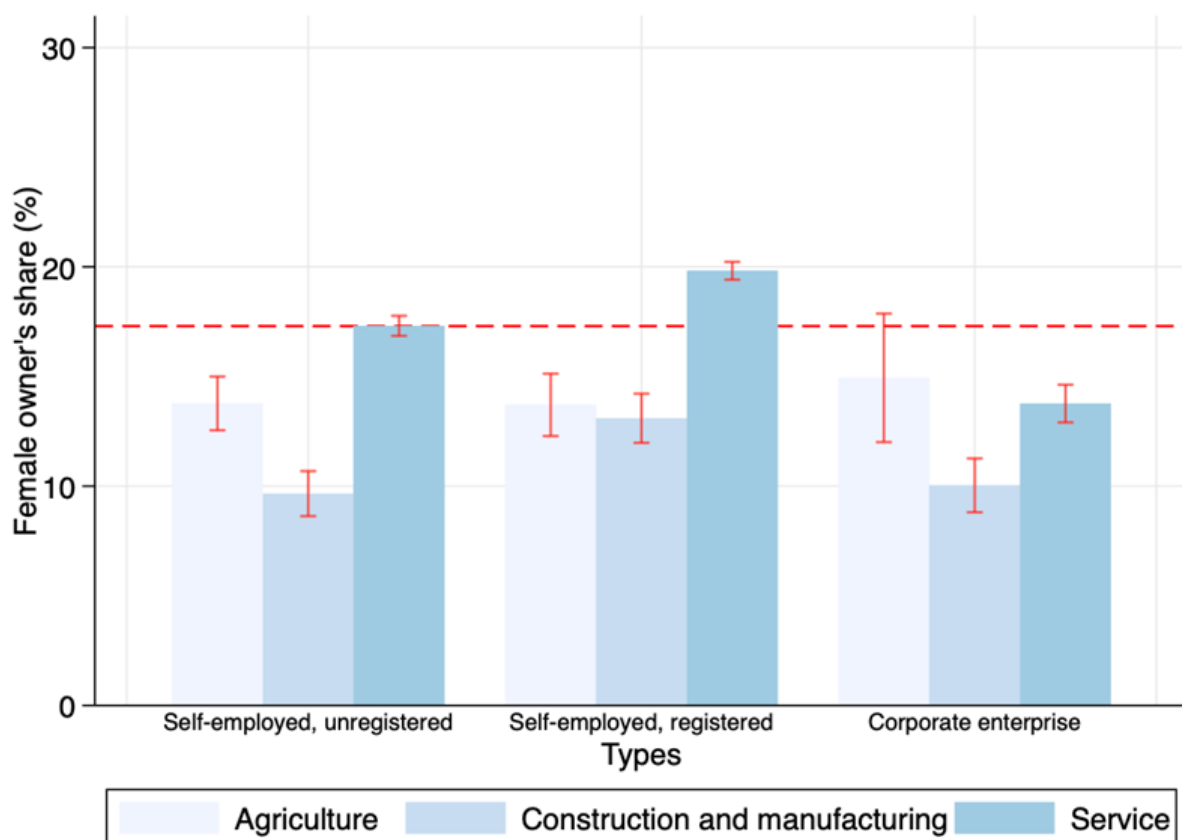
Table 9: Impact of Local Outbreak and Prevention and Control Measures on Telecommuting and Electronic Information Systems of Small and Micro Operators, by Gender

	(1) Telecommuting	(2)	(3) Introduction of Electronic Information System	(4) Sales	(5) Finance Payments	(6) Management Production
Panel A: Female Operators						
COVID x After	0.034* (0.020)	0.030* (0.014)	-0.023 (0.016)	-0.029 (0.024)	-0.009 (0.016)	0.003 (0.011)
Mean Value of Dependent Variable	0.110	0.150	0.128	0.293	0.216	0.063
Standard Deviation of Dependent Variable	0.312	0.357	0.335	0.455	0.411	0.243
Adj. R-sq	0.090	0.000	0.001	-0.021	0.006	-0.003
Observations				11,186		
Panel B: Male Operators						
COVID x After	0.019 (0.009)	0.010 (0.008)	0.008 (0.011)	0.012 (0.015)	0.006 (0.012)	0.006 (0.009)
Mean Value of Dependent Variable	0.116	0.145	0.148	0.258	0.236	0.093
Standard Deviation of Dependent Variable	0.321	0.352	0.355	0.438	0.425	0.291
Adj. R-sq	0.099	0.057	0.078	0.025	0.069	0.042
Observations				53,850		
Control Variables	Yes	Yes	Yes	Yes	Yes	Yes
Quarterly Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
Urban Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
Industry Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
City-Industry Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
City-Annual Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
Industry-Annual Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes

Note: All regression results reported in the table use OLS estimation, and consistent results are obtained under the Logit model. Standard errors for clustering to the city level are reported in parentheses. COVID $\times$ After takes the value of 1 after the city where the micro and small operator is located is subject to a localized outbreak of new crown pneumonia and preventive and control measures such as a lockdown, and 0 otherwise. Control variables include firm age, operator age, type of operation, employee size, and quarterly operating income. The regressions also control for city, industry, and quarterly fixed effects, as well as city-industry, city-year, and industry-year bivariate fixed effects. The sample from the third quarter of 2020 is excluded from this table analysis due to the absence of relevant questions. Significance levels: * $p < 0.1$ ** $p < 0.05$ *** $p < 0.01$

Data source: OSOME.

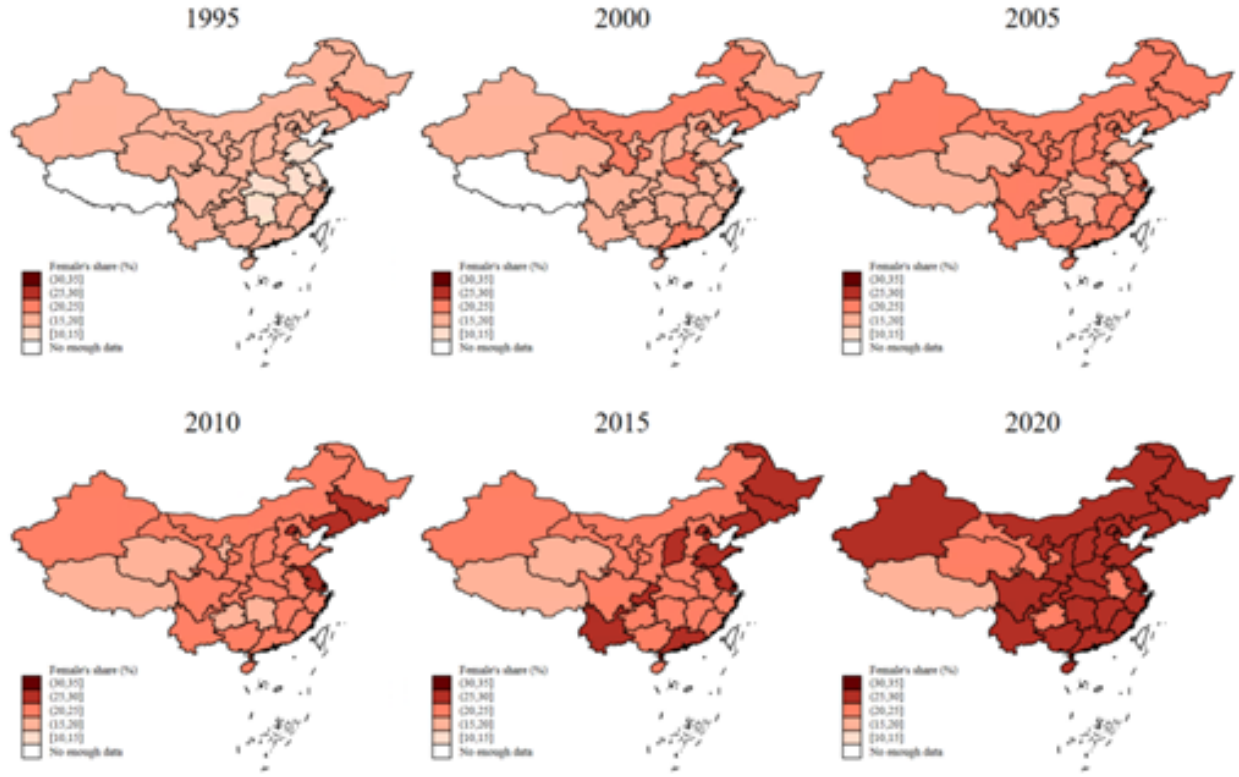
Figure 1: Proportion of Women Among Micro and Small Operators in Different Industries and Registration Types in the OSOME Sample



Note: The reported proportion is the proportion of female micro and small operators (%), and the vertical line indicates the 95% confidence interval. The horizontal line indicates the full sample mean.

Data source: OSOME.

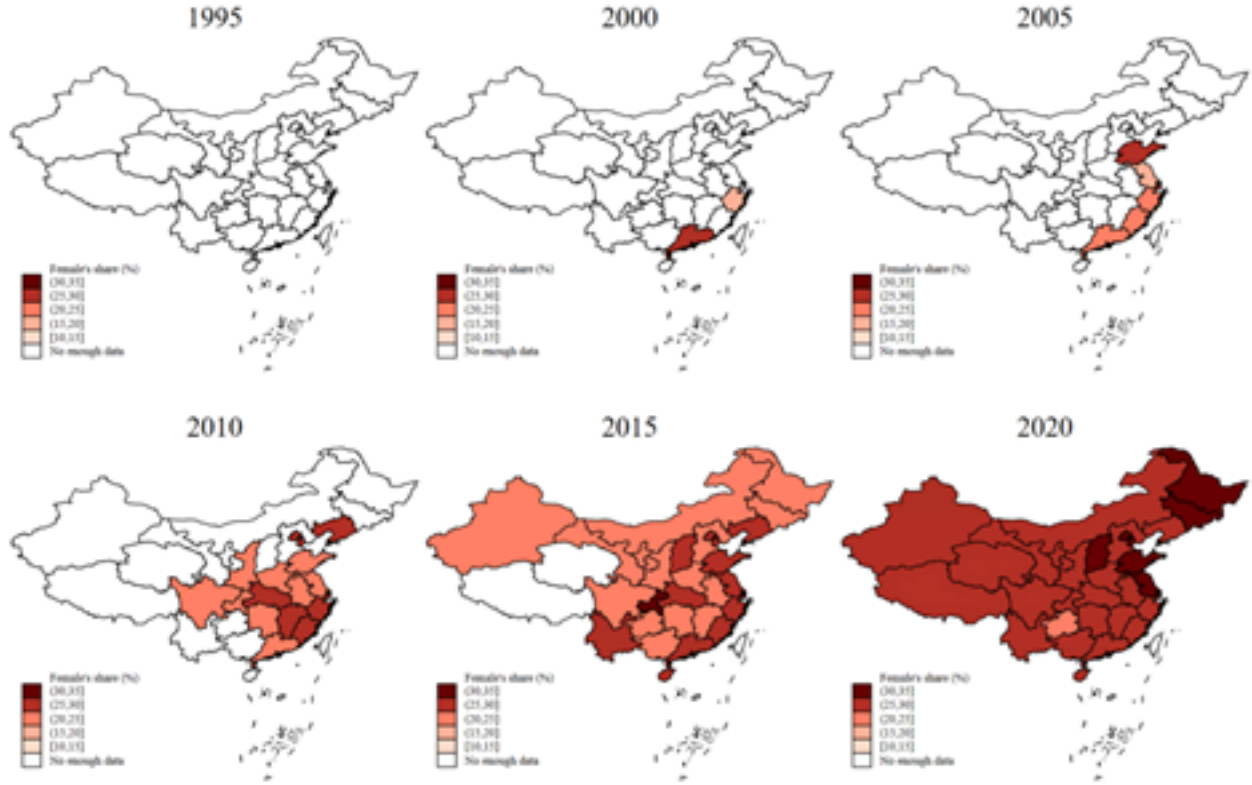
Figure 2: Distribution of New Women-Run Enterprises in China in 1995-2020



Note: The proportion of female entrepreneurs is calculated based on the proportion of women among the legal representatives of all new enterprises, with darker colors indicating a higher proportion of female legal representatives. Observations with less than 500 new enterprises are excluded (no color-filled part in the figure). The gender of legal representatives is obtained according to the gender inference algorithm of this paper for their names.

Data source: China business registration data.

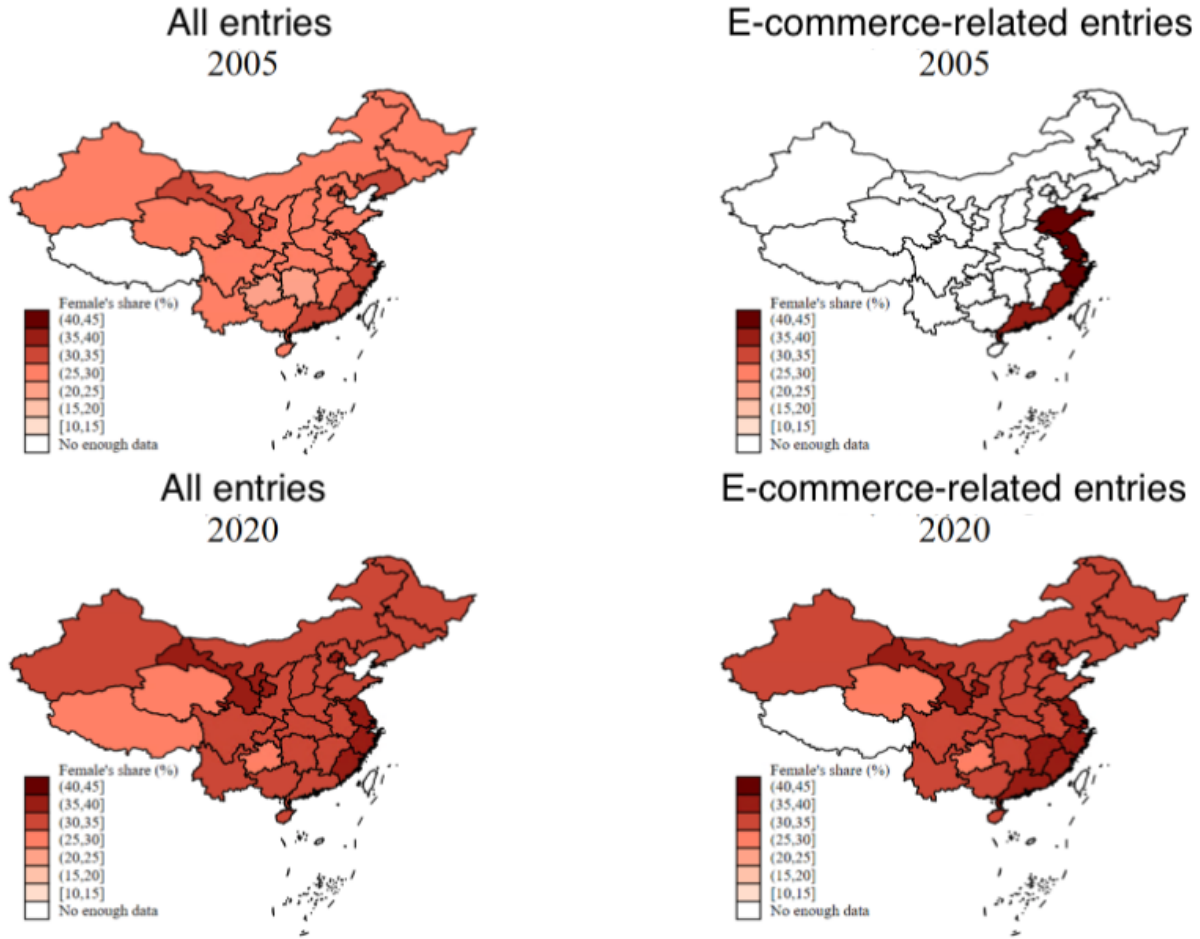
Figure 3: Distribution and Change of the Proportion of Female Entrepreneurs in New E-Commerce-Related Enterprises in China, 1995-2020



Note: The proportion of female entrepreneurs is calculated based on the proportion of women among legal representatives of "e-commerce related" newly established enterprises, and the darker the color, the higher the proportion of female legal representatives. Observations with less than 500 new enterprises are excluded (no color filled part of the graph). The gender of legal representatives is calculated according to the gender inference algorithm in this paper; the classification of "e-commerce related" enterprises is calculated in Cong, Yang, and Zhang (2021) according to the classification of "e-commerce-related" enterprises

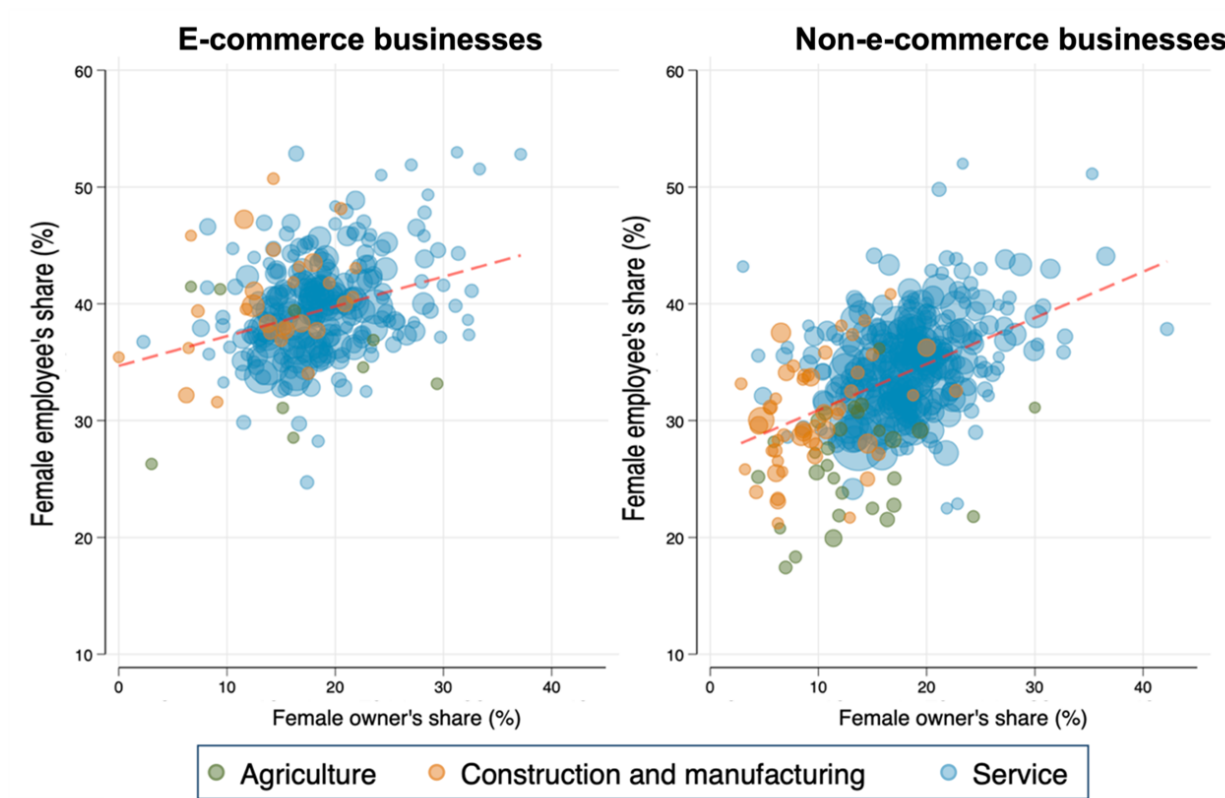
Data source: China business registration data.

Figure 4: Distribution and Change in the Proportion of Female Executives in New Enterprises (all, e-commerce) in China, 2005-2020



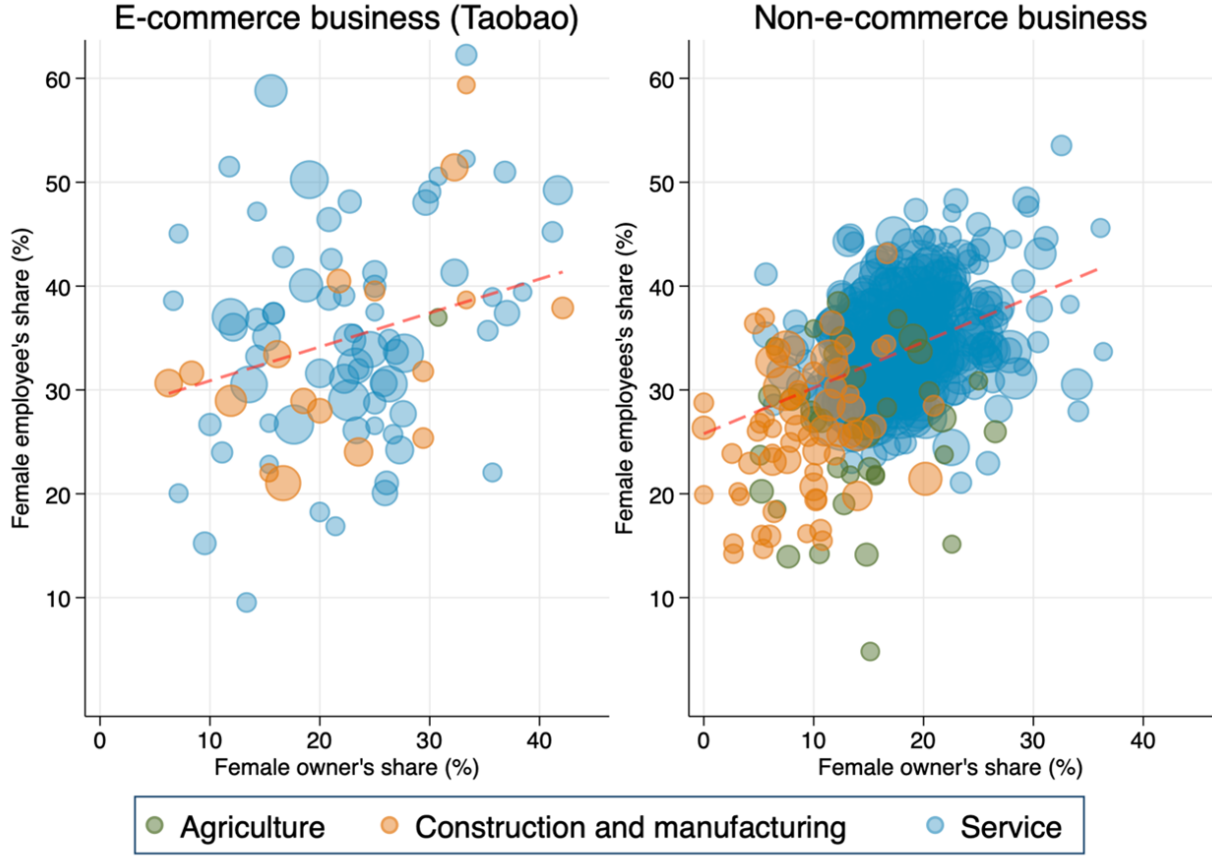
Note: The proportion of female executives is calculated based on the proportion of female executives who are not legal representatives in new enterprises, and is calculated separately for all new enterprises and "E-commerce related" new enterprises. The darker the color, the higher the proportion of female executives (non-statutory representatives). Observations with less than 500 new enterprises were excluded (no color-filled part of the graph). The gender of executives is calculated according to the gender inference algorithm in this paper; the classification of "E-commerce related" enterprises is calculated based on the text analysis algorithm of enterprise business scope (Cong, Yang, and Zhang 2021). Data source: China business registration data.

Figure 5: Proportion of Female Micro and Small Operators Versus Female Employees, by E-Commerce Operators Versus Non-E-Commerce Operators



Note: The bubble size indicates the sample size of micro and small operators at each city-industry level and excludes groups with sample size less than 15.
Data source: OSOME.

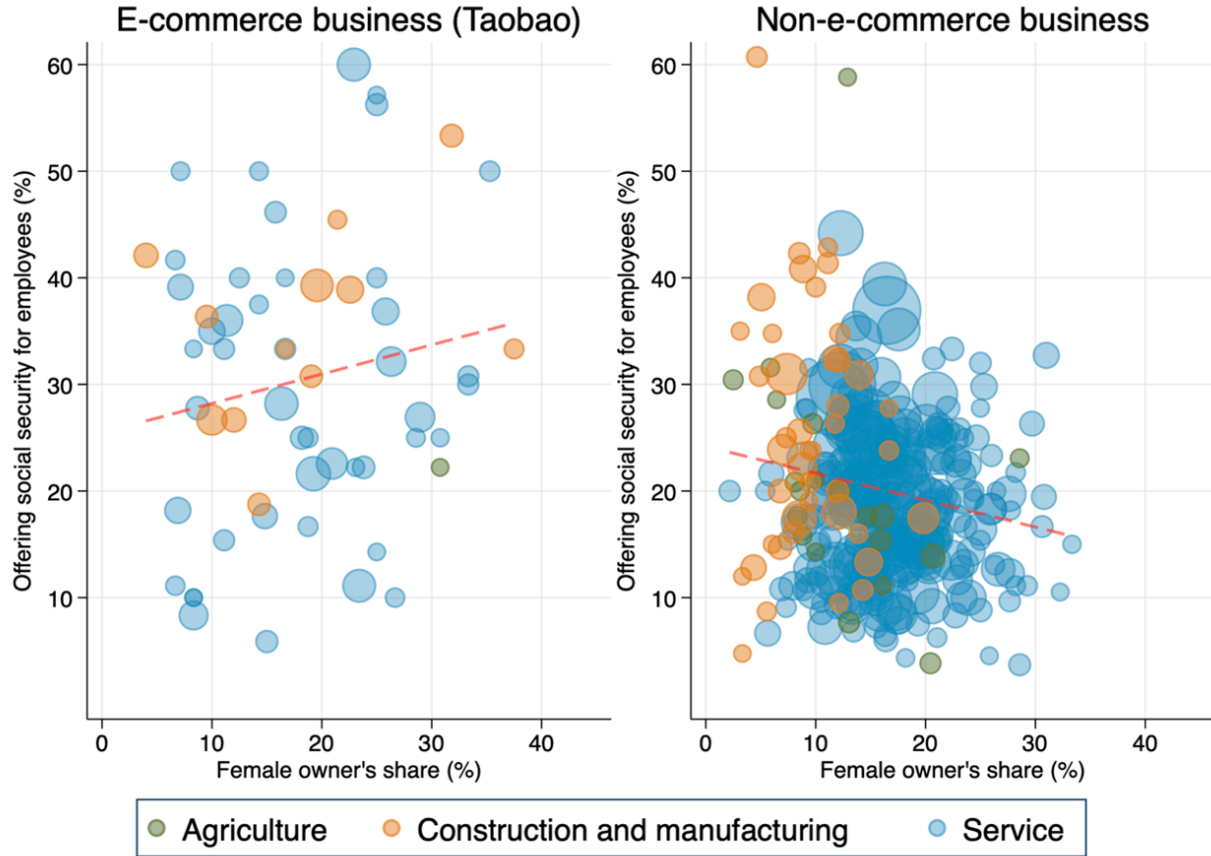
Figure 6: Proportion of Female Micro and Small Operators Versus Female Employees (established before 2020), by Taobao Merchants and Non-Taobao Merchants



Note: The bubble size indicates the sample size of micro and small operators at each city-industry level and excludes groups with a sample size of less than 15. The sample is limited to small and micro-operators established before 2020 and excludes operators in cities localized Covid outbreaks at the time of interview.

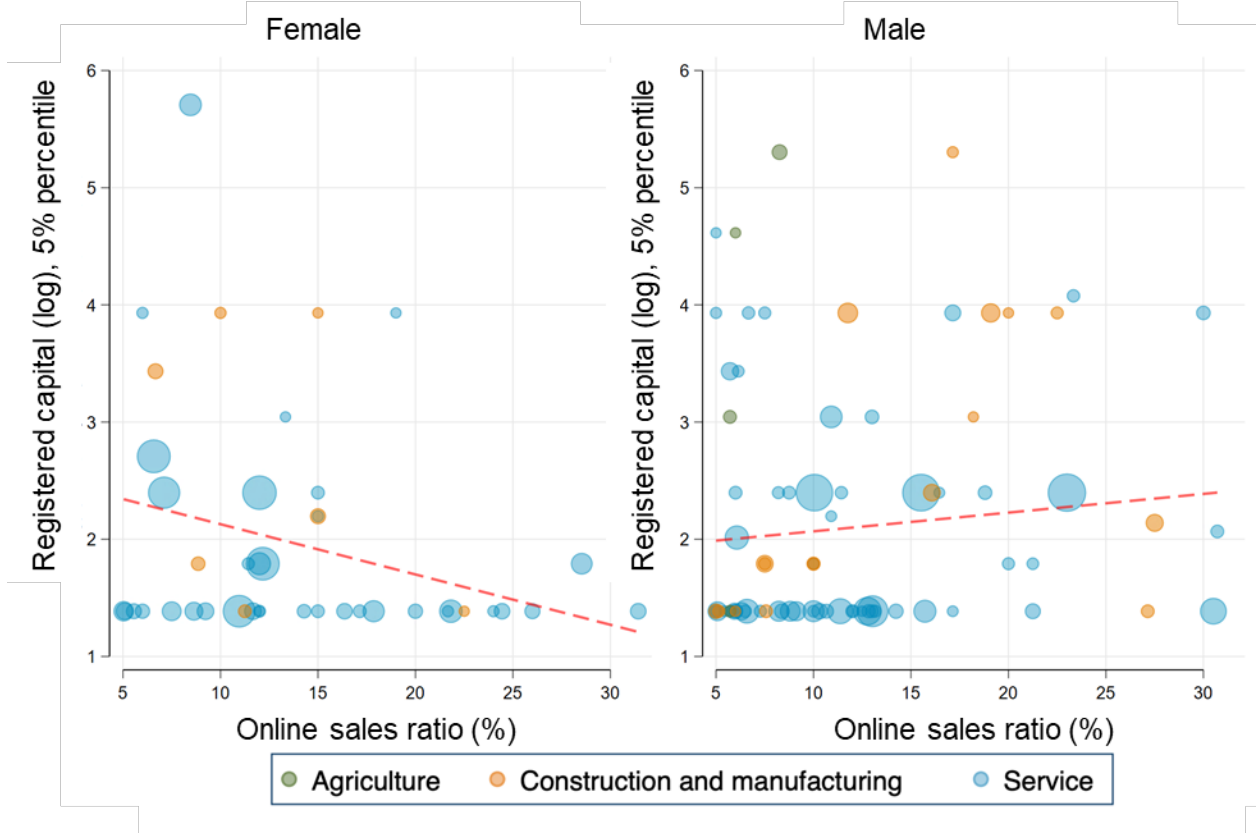
Data source: OSOME.

Figure 7: Proportion of Female Micro and Small Operators Versus Full-Time Employees' Social Security Contributions (established before 2020), the Breakdown of Taobao Merchants and Non-Taobao Merchants



Note: The bubble size indicates the sample size of micro and small operators at each city-industry level and excludes groups with a sample size of less than 15. The sample is limited to small and micro-operators established before 2020 and excludes operators in cities localized Covid outbreaks at the time of interview. This figure also excludes the sample from the survey in the third quarter of 2020 in the analysis due to the absence of relevant questions in the questionnaire. Data source: (OSOME).

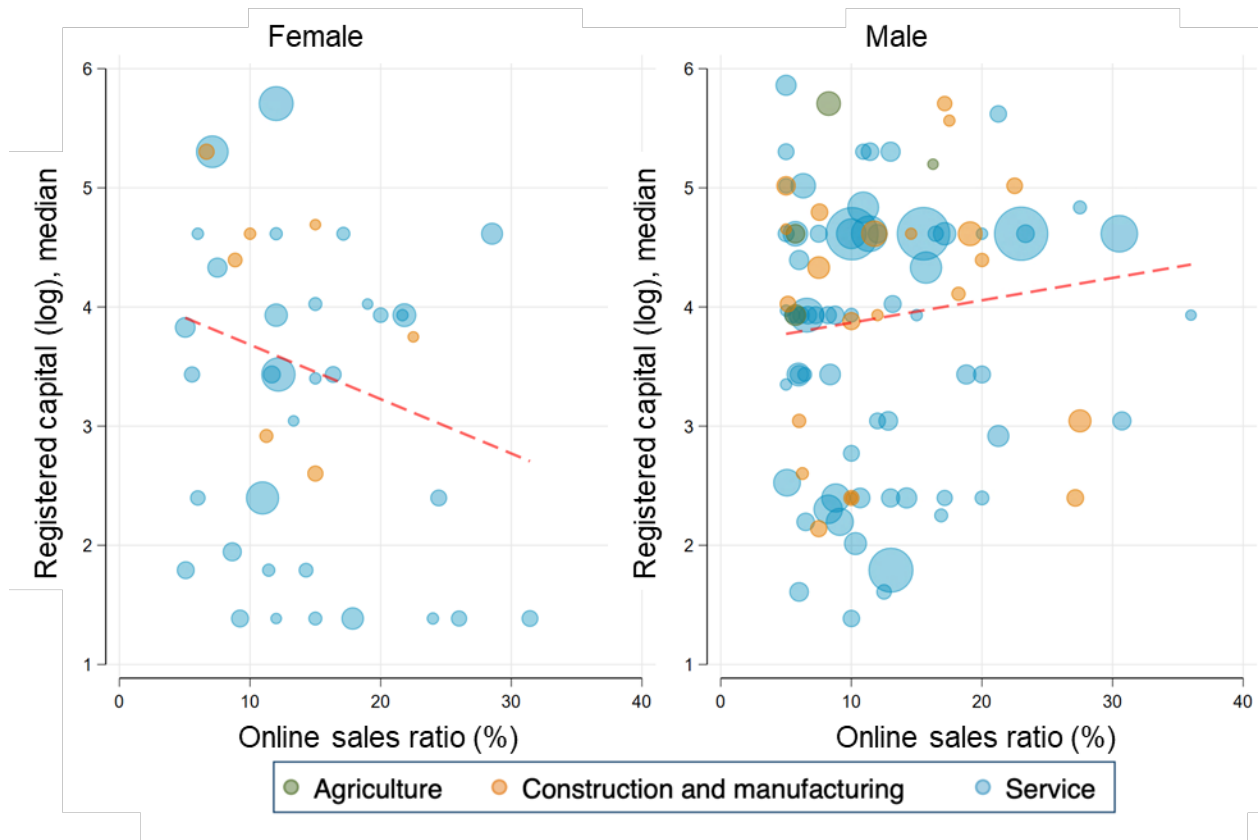
Figure 8: Lower 5% Quartile Level of the Proportion of Online Sales Versus Registered Capital, by Operator Gender



Note: The bubble size indicates the number of samples at each city-industry level and excludes groups with sample size less than 15.

Data source: Enterprise Survey for Innovation and Entrepreneurship in China (ESIEC), China business registration data.

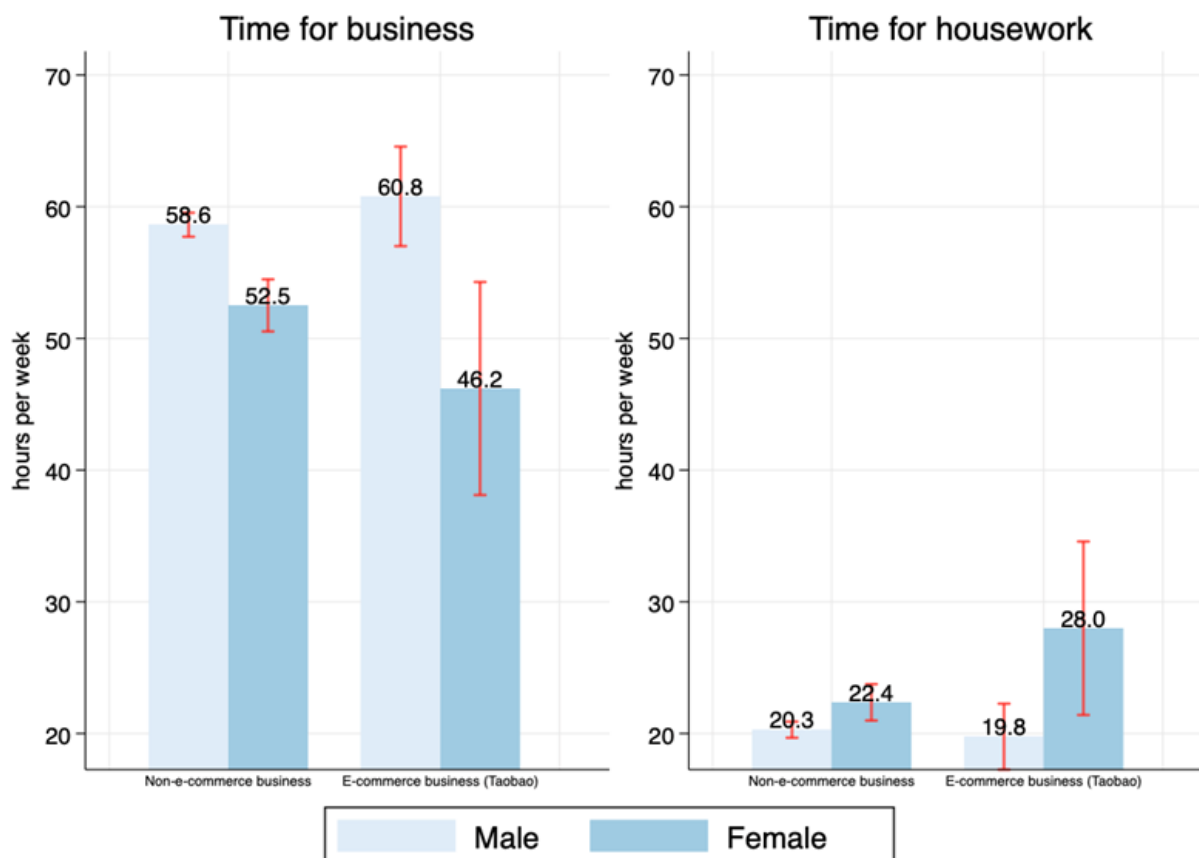
Figure 9: Median Level of Online Sales Ratio vs. Registered Capital, by Operator Gender



Note: The bubble size indicates the number of samples at each city-industry level and excludes groups with sample size less than 15.

Data source: ESIEC, China business registration data.

Figure 10: Average Weekly Time Spent Running a Business and Handling Household Chores by Micro and Small Operators, by Type of Business and Operator Gender



Note: Vertical lines indicate 95% confidence intervals. The figure uses only the sample of the first quarter of the 2022 survey which includes specific questions on time allocation. The sample is limited to small and micro-operators established before 2020 and excludes operators in cities localized Covid outbreaks at the time of interview.

Data source: OSOME.