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

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Abstract

Female entrepreneurial activities are underrepresented in both developed and developing countries because of various constraints facing women entrepreneurs. To unleash their potential, it is essential to remove the impediments. Using primarily collected online and offline enterprise surveys and administrative data in China, this paper shows that expanding e-commerce and digital marketplaces has promoted female entrepreneurship and employment by addressing some impediments. Moreover, in the face of COVID-19 shocks, women entrepreneurs are more likely to adopt e-commerce and other digital technologies.

Keywords: Entrepreneurship, Gender gap, E-commerce, Digital Economy

1. Introduction

Entrepreneurship is a key driver of economic growth and job creation (Baumol, 1990; Fonseca et al., 2001; Li et al., 2009). However, the female participation rate in entrepreneurial activities is significantly lower than men's (Aldrich, 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 (Sauer & Wilson, 2016; Greene et al., 2001; Becker-Blease & Sohl, 2007; Brooks et al., 2014; Guzman & Kacperczyk, 2019; Ewens & Townsend, 2020). Some innate gender differences, such as in risk preference, are another frequently mentioned contributing factor (Klapper & Parker, 2010; Croson & Gneezy, 2009; Bertrand, 2011). Lack of social networks and unfavorable social institutions are also 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 worldwide. However, it is hard to overcome these challenges and boost female entrepreneurship in a short time using traditional means. One option is to look at

[1] The 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.

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

countries with rapid improvement in female entrepreneurship and examine the underlying drivers. Our paper focuses on China, a country with a rapid rise in female entrepreneurs.

According to the business registration dataset maintained by 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 most successful women entrepreneurs."[3] As a comparison, about 19.1% of small businesses in the US are owned by women.[4] 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 China's rapidly rising female entrepreneurship and the narrowing gender gap?

The major explanations mentioned above on the gender gap in entrepreneurship do not seem to answer the question well. First, in the past several decades, no special policies in China have targeted female entrepreneurs for credit support. The existing gender bias against female entrepreneurs in access to traditional external credit, if at all, has 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 the gender gap in entrepreneurship but not the trend of narrowing the gap. Third, it is hard to attribute the rising female entrepreneurship to a 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

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

force participation rate, as women generally prefer stable formal employment to informal employment and entrepreneurial activities, as shown in the literature (Carranza, Dhahal, and Love, 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 female entrepreneurship in China. In the past two decades, e-commerce in China has also grown from scratch and become the world's largest e-commerce market (Cong, Yang, and Zhang, 2021; see also Appendix Figure A7). More than 40% of the online stores on Alibaba's e-commerce platform are run by women, which is 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 e-commerce and digital economy era, women entrepreneurs' financial constraints have been lessened. Lenders can use Fintech models to extend online credit to many micro and small enterprises with digital footprints, which traditional banks previously underserved due to the lack of collaterals. Because women entrepreneurs account for a larger share of online businesses than in traditional sectors, and Fintech is gender blind in extending credit, more female entrepreneurs have naturally gained access to online credit (Zeng, Ma, and Zhang, 2022). In addition, e-commerce can lower the threshold to start a business, which mainly benefits women entrepreneurs as they are more financially constrained.

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

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 balance family and work obligations. Thanks to digital technologies, some constraints have become less binding for women entrepreneurs in the age of the digital economy.

To test the hypothesis, we used a combination of administrative and survey data, including business registration database, JD.com e-commerce transaction data, and online and offline survey data on micro and small-sized enterprises. Textual analysis is used to predict the gender based on their Chinese names 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 JD.com e-commerce transaction data and take advantage of the rolling out of the "*JDBang*" 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 male counterparts.

Our paper contributes to several strands of literature. First, it is related to the 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 participation and business opportunities (58%). 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 the digital economy.

Our study is related to the literature on the economic effect of e-commerce and digitization. The previous literature has mainly studied the impact of e-commerce on various outcomes, such as residential consumption (Fan et al., 2018; Luo et al., 2019; Couture et al., 2021), and merchant behavior (Bai et al., 2020; Yang et al., 2021). This paper focuses on the impact of e-commerce on women's entrepreneurship, which has been less discussed in the literature (Vossenberg, 2013). It thus adds to the emerging body of literature on the digital divide and entrepreneurship in developing economies.

Our paper is also associated with the recent literature on the impact of COVID-19 on SMEs. A few studies show that the COVID-19 pandemic more negatively impacted working women because of the increasing burden of family caregiving during COVID restrictions (Alon et al., 2020; Graeber et al., 2021). Our paper finds that to cope with the negative shock, women entrepreneurs are more likely to adopt e-commerce and other digital business tools than male entrepreneurs. The finding is consistent with a few business reports. According to the 2020 MasterCard Index of Women Entrepreneurs, "42% of women entrepreneurs have turned to digital business models since the pandemic."[7] One study on the e-commerce platform eBay also shows more women engaged in e-commerce during the pandemic.[8]

[7] https://www.mastercard.com/news/media/1ulpy5at/ma_miwe-report-2020.pdf.
[8] https://www.ebaymainstreet.com/empowering-women-sellers-report.

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 shows that women entrepreneurs are more likely to adopt digital business tools such as e-commerce to cope with the COVID-19 restrictions. Finally, section 6 concludes with a summary and discussion.

2. Literature Review on Female Entrepreneurship and the Gender Gap

Much of the established academic literature has found significant differences between female and male entrepreneurs in terms of behavior and outcomes, including many aspects of business start-up, survival, financial support, and business performance, such as the reviews conducted by De Vita et al.(2014) and Klapper and Parker(2010). Of these, studies on entrepreneurship have focused on the factors that tend to make women make entrepreneurial decisions, including literature related to female labor participation.

Some literature tends to argue that differences in preferences between men and women cause the gender gap in entrepreneurship. The literature is based mainly on psychological and economic experiments (Croson & Gneezy, 2009; Bertrand, 2011), including studies on entrepreneurship that also reflect differences in preferences between men and women, giving evidence on differences in preferences, sources (innate or acquired), and possible economic effects related to business performance. In terms of risk preferences, most experimental studies point out that women are more risk averse than men (Eckel & Grossman, 2008; Croson & Gneezy, 2009; Dohmen et al., 2011; Charness

& Gneezy, 2012) and therefore have a lower propensity to start a business (Koellinger et al., 2013; Huang and Kisgen, 2013). Further, it was found that female executives are more risk-averse than male ones. Risk aversion in women may be caused by genetic differences, such as the difference in testosterone production levels between men and women as reflected by the length ratio of the index finger to the ring finger (2D:4D ratio), which has also been shown to be associated with risky behavior (Sapienza et al., 2009; Guiso & Rustichini, 2018).[9] The difference in testosterone levels between men and women, as reflected by the index finger to ring finger length ratio (2D:4D ratio), for example, has also been shown to be associated with risky behaviors. Regarding overconfidence, the literature finds that men are more likely to be overconfident than women (Bengtsson et al., 2005). In addition, male business executives exhibit more overconfidence traits (Niederle & Vesterlund, 2011; Huang & Kisgen, 2013). In terms of altruistic preferences, women are more inclined to express concern and responsibility for the well-being of others (Beutel & Marini, 1995). As a result, women are generally more willing to donate (Andreoni & Vesterlund, 2001). Female executives have also been found to be more friendly to female employees (Tate & Yang, 2015). In terms of competitive preferences, some studies have shown that women are less willing to engage in competition than men (Beutel & Marini, 1995; Niederle & Vesterlund, 2007; Croson & Gneezy, 2009)and that competitive environments may be less motivating for women than for men (Gneezy et al., 2003). This has led to a lower probability of female entrepreneurship (Bönte & Piegeler, 2013) and poor performance (Amore & Garofalo, 2016). Regarding homophily preferences, studies have found that homogeneity in gender, race, and educational background increases the likelihood of team formation and makes women less likely to enter industries dominated by male entrepreneurs (Gompers et al.,

[9] It has also been suggested that the differences in risk preferences between men and women may reflect the influence of the environment (Booth et al., 2014).

2017). In addition, studies have also pointed out that women value flexibility in their career choices, such as a preference for part-time work (Booth & Van Ours, 2008, 2013; Le Barbanchon et al.2021). Meekes and Hassink (2022) also found that women's preference for job flexibility after leaving their jobs resulted in shorter working hours and commuting distances to their new jobs.

The literature, on the other hand, emphasizes the importance of external factors. First, much of the existing research identifies financial disincentives as a significant barrier to new firm establishment, and women are subject to more significant liquidity constraints (Sauer & Wilson, 2016) and have less access to venture capital (Greene et al., 2001; Becker-Blease & Sohl, 2007; Brooks et al., 2014; Guzman & Kacperczyk, 2019; Ewens & Townsend, 2020). In addition, female-managed firms attract less investment at the IPO stage (Bigelow et al., 2014). The Sri Lankan experiment shows that financial subsidies and business training promote local women's entrepreneurial behavior. Second, the family environment is an important factor influencing women's entrepreneurial decisions. Childbirth and childcare negatively affect women's willingness to work and their performance but increase the likelihood of choosing entrepreneurship or self-employment when deciding to work (Song & Dong, 2017; Guo et al., 2018). This is mainly due to the better flexibility in 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 (Zanderberg, 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, fair social norms, social welfare structures, and greater female political participation are positively associated with female entrepreneurship.

The discussion on female entrepreneurs and executive business performance, on the other hand, has yet to reach a consistent conclusion. Many studies have found that firms with female executives or directors have lower financial indicators (e.g., profits) than other firms, but female executives or directors perform better on specific issues involving risk. In terms of entrepreneurial performance (Jayachandran, 2020), gender differences in formalization, credit financing, business training, and hiring were found for micro and start-up businesses. 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). Hebert (2020) shows that female-founded startups are found to have less access to external equity financing, including venture capital, but can gain some advantage in female-dominated industries. In terms of corporate governance, female-owned businesses have less access to bank loans and are charged higher interest rates (Muravyev et al., 2009), suggesting that female entrepreneurs still face financial constraints even after successful start-ups. The average impact of board diversity on firms is also somehow negative, as shown by Ahern and Dittmar(2012) and Matsa and Miller(2013). The average impact of board gender diversity on firms is also more negative (Adams & Ferreira, 2009), as Ahern and Dittmar (2012) and Matsa and Miller (2013) use the Norwegian board gender quota method as a shock and find that it leads to lower share prices, Tobin's Q value, and board professionalism, and reduces firm labor hiring, increases labor costs, and reduces short-term profits.

On the other hand, the literature argues that female entrepreneurs reduce governance risk. In Europe, women-run firms 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 less likely to engage in acquisitions (Huang & 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.

3 Data Description

3.1 Data Source

We assemble several large-scale data sets (including both manually collected primary data and proprietary data from the administration and the e-commerce platform) concerning small and medium-sized enterprises and entrepreneurs in China. The scale and coverage of the data mark one main contribution.

SAIC Business registration dataset. 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 make 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 most firm-level databases. This could be more critical to our research as women are more prone to start a business in informal sectors.

In contrast, China's commonly used Annual Survey of Industrial Firms (ASIF) covers manufacturing enterprises with annual sales over a threshold of 5 million RMB. It contains most large Chinese firms while leaving out MSMEs in the manufacturing sector and all the firms in the service sector that make up the majority of Chinese firms. While

the sample is limited to the registered enterprises, the other survey data complement more detailed information on self-employment.

However, since gender information is not included in the business registration dataset as it is highly confidential and privacy-sensitive, this paper later develops a machine-learning textual analysis algorithm to infer entrepreneurs' gender from their Chinese-given names, which we will describe in detail in the following subsection. This paper first aggregates the annual entry information of newly-built enterprises between 2005 and 2020 from the business registration dataset and matches the names and positions of the legal representatives. We then apply the algorithm 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 JD.com e-commerce transaction data, this paper sums up variables such as the number and proportion of female entrepreneurs or executives in new entrant 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 textual analysis method for business operation scope by Cong, Yang, and Zhang (2021) to calculate the share of female entrepreneurs and executives engaged in e-commerce and non-e-commerce operations, respectively.

In the ESIEC field survey, we explicitly asked if the couple ran a business together. Among 3,792 entrepreneur respondents, only 207 (5.5%) reported that they ran a family business. Linked to the business registration dataset, the survey data shows that 65.7% (136/207) of the family business registered the male as its legal representative, while only 34.3% registered the female. Therefore, in our analysis using the registered legal representative as the entrepreneur, it is more likely to underestimate the contribution of females in family businesses.

JD.com e-commerce transaction data. Following Cong et al. (2021), to quantitatively analyze the impact of e-commerce expansion on female entrepreneurship, this paper also incorporates e-commerce transaction data from JD.com. The e-commerce transaction data includes panel quarterly transactions for a total of 214 districts and counties in different regions of China aggregated at the regional and product category levels from the first quarter of 2015 to the third quarter of 2019. Appendix Tables A1 and A2 provide balance checks for the sampled counties and the *JDBang* program. Through the linkage between industries and product categories (indicated by the official *Product Categories for Statistical Purposes* by the National Bureau of Statistics of China), we match the products and services in the e-commerce transaction data with their corresponding processing manufacturing or service industries. Furthermore, this paper uses sales on the JD.com platform in the sample districts and counties to measure local e-commerce development induced by the e-commerce expansion and as the primary explanatory variable in the baseline analysis. This measurement is the original data source of the county or municipal e-commerce activity indices released by relevant institutes (e.g., e-commerce sales indices by Alibaba Research), and it can be further refined to the industry or product level. In this way, we construct a dataset containing both e-commerce expansion and female entrepreneurship.

Online Survey of Small and micro enterprises in China (OSOME). To alleviate the measurement error due to the textual-based analysis to some extent and to cover more self-employed businesses, this paper also combines micro-level data from the OSOME survey for analysis. The online OSOME survey is conducted on the most widely used e-payment platform, Alipay, focusing on active small and micro business users. The questionnaire mainly includes topics on business operation performance, owners' personal information, aspects of digital adoption (online sales, remote work, and adoption of electronic information systems), and business challenges. The quarterly survey

receives nearly 10,000 responses per quarter, with samples covering unregistered self-employed, registered self-employed, and incorporated enterprise businesses. The sample of unregistered self-employed businesses accounts for nearly 40%, which has been largely neglected and underestimated in previous studies while it is important to informal sectors and females.

In the OSOME survey, female MSMEs account for about 17.3% of the sample collected from the third quarter of 2020 to the fourth quarter of 2021, concentrated in the service industry, and their business types are primarily self-employed (including registered and unregistered), as shown in Figure 1. Also, the questionnaire includes questions about SMEs' business performance, financing, post-COVID-19 recovery, online operation, digital transformation, current major challenges, expectations for the future, and operators' personal basic information, enabling us to further examine women entrepreneurs' adoption of digital business beyond e-commerce.

The OSOME survey includes a few more questions on business operation type (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, making it possible for us to accurately identify the e-commerce business in the sample based explicitly on whether they are registered sellers on Taobao, which holds a major market share in the Chinese e-commerce market.[10] Nevertheless, not observing businesses on other platforms will more likely lead to an underestimation. In the respondent sample, the proportion of female-owned businesses in Taobao sellers is 21.2%, which exceeds the average of 17.3% in the sample.[11] In addition, in the robustness analysis, we also exclude MSEs established after 2019 and the

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

[11] This 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".

sample from cities hit by the COVID-19 pandemic at the time of the survey to mitigate the impact of the pandemic shock. In the first quarter of 2022, the OSOME questionnaire includes a few more 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 and intrahousehold bargaining power. In addition, the OSOME data contains information on the location of MSMEs at the prefectural level, thus allowing us to match the manually collected information on sporadic outbreaks and corresponding lockdowns to assess the impact of COVID-19 on the adoption of e-commerce and other digital transformations by female and male MSMEs, respectively.

Figure 1 here

Enterprise Survey of Innovation and Entrepreneurship in China (ESIEC). ESIEC is an entrepreneur and enterprise-specific field survey project led by Peking University covering six provinces. ESIEC successfully interviewed nearly 10,000 private enterprise owners and self-employed entrepreneurs between 2017 and 2019, collecting high-quality microdata on the entrepreneurs' backgrounds and business performance. It is representative nationwide regarding industry or firm size distributions (Dai et al., 2021a; Xu et al., 2022).

3.2 Algorithm to Identify the Gender of Entrepreneurs

Although the business registration dataset publicizes detailed information about registered enterprises, the gender information is confidential and unavailable. 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 mainly inherited from the father, while the family elders normally pick up the given name according to various factors such as time, clan, gender, traditional culture (e.g., poetry, zodiac sign, “five elements”), and expectations for the offspring.[12]

Some relevant studies in the literature 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) found, through a similar experiment, that the Toronto job market discriminates among 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). However, 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 implicit gender information in names can interfere with performance (Fershtman & Gneezy, 2001; Charness & Gneezy, 2008). The scenario in this paper alleviates these issues as Chinese names contain less information related to ethnicity and race. Similarly, Tang and Zhang(2021) have shown the correspondence between Chinese given names and gender, calculated by census data and applied to the data of above-scale industrial

[12] The 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 in 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.

enterprises to infer the gender of the legal representatives of the enterprises. With the above cultural tradition and the same spirit in the literature, we develop the method to infer gender through Chinese names, as Appendix A details.

After completing the gender inference based on Chinese-given names, we select the indicators of female entrepreneurship. First, in terms of female entrepreneurship, we use the proportion of female entrepreneurs in new entries as a measure.[13] The definition of "entrepreneur" varies depending on the research question (Wang, 2020). Based on the field survey, registration regulations, data characteristics, and literature, we define the "entrepreneur" in this paper as the legal representative of a newly established enterprise. First of all, the legal representative is usually the core founder of the enterprise during the field survey (Dai et al., 2019). It is also noted that 75% of the legal representatives are also the largest shareholders of the enterprise. Also, for many MSMEs in the dataset, only the legal representative is registered at the time of registration. In particular, the business registration reform since 2014 has largely 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, allowing us to establish the linkage between personal and enterprise information. The definition is also consistent with Dai (2017), Shi et al. (2021), and Chen et al. (2022). Further, as a robustness check, we also use a broader (including executives) or narrower (legal representatives must also serve as executives) definition for the analysis, which has no impact on the empirical results and is consistent with previous studies (Wang, 2020). Based on this, this paper mainly reports the results using the definition of "legal representative."

[13] Observations 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.

4. Empirical Analysis

4.1 Baseline Empirical Strategy

Following Cong et al. (2021), we first use the Bartik-style (shift-share) instrumental variable identification framework based on JD.com e-commerce transaction data and the "*JDBang*" e-commerce promotion program to casually quantify the impact of e-commerce expansion on female entrepreneurship in China. Cong et al. (2021) provide detailed evidence that JDBang, an e-commerce promotion program led by JD Logistics, significantly contributes to the growth of local purchase demand on the JD.com e-commerce platform. Combining this demand shock with the pre-determined inter-regional trade network, we construct the Bartik instrumental variable to examine the impact of demand shocks of the JD.com e-commerce platform on firms providing the product or services.

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

$$ln(Sales)_{ijt} = \theta_1 \times B_{ijt} + \theta_2 \times \left(\sum_{d \neq i} \omega_{ijd,t=0}\right) + '\theta + FEs + \varepsilon_{ijt} \quad , \tag{1}$$

where B_{ijt} is the Bartik instrumental variable constructed as in Cong et al. (2021), and we control for the sum of Bartik weights $\sum_{d \neq i} \omega_{ijd,t=0}$ to avoid potential statistical errors (Borusyak et al., 2022). $ln(Sales)_{ijt}$ is the "e-commerce index" defined above, i.e., the sales on the e-commerce platform of the sampled districts and counties of JD.com e-commerce transaction data, which is used to reflect the active participation of local enterprises in e-commerce. Although JD.com is leading the competition in China's e-commerce market, it does not hold the vast majority of the market share so that the analysis results may be underestimated. 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. We also control for district-industry and quarterly fixed effects.

The second stage of the Bartik regression was set as follows:

$$Y_{ijt}=\beta_1 \times ln(\widehat{Sales})_{ijt} +\beta' \mathbf{X}_{i,t-4}+ 'FEs+\varepsilon_{ijt}I \quad (2)$$

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 included as in (1), and the standard deviations of the regressions are clustered to the 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.

To test the potential channels, we focus on the dummy variables of gender, whether it is an e-commerce business, and the interaction term to reflect the e-commerce channels on female entrepreneurship. The specific settings are as follows:

$$Y_i=\beta_1 \times (Female \times Ecom)_i+\beta_2 \times Female_i+\beta_3 \times Ecom_i+\mathbf{x}'_i\theta+FEs'\varepsilon_i \quad (3)$$

where $Female_i$ is a dummy variable for female business owners, and $Ecom_i$ is a dummy variable for e-commerce businesses.

4.2. Empirical results

Table 1 shows the baseline regression results on the impact of e-commerce demand expansion on female entrepreneurship. Column (1) examines the effect on the extensive margin and shows that the demand shock does not encourage female entrepreneurs to enter local industries where few women were previously involved. In columns (2) and (3), we examine the number and proportion of female entrepreneurs at the intensive margin. The demand shock of e-commerce expansion significantly increases the number of female entrepreneurs among new entries, with an estimated elasticity of nearly 0.678

concerning sales growth on the JD.com e-commerce platform. At the same time, the proportion of females 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 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 JD.com e-commerce platform of 25.4% during this 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 female executives in new entries 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 more impacted by the e-commerce demand shock have more women serving as executives in new entries. 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 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 their career, but on the other hand may also reflect that women still face strong external constraints such as financial

disincentives. Second, the results in columns (2) and (3) also show that the number and proportion of female executives in new firms have significantly increased due to the impact of e-commerce expansion.

Table 2 here

Furthermore, based on the "business operation scope" textual record in the business registration dataset, we can examine the entrepreneurial heterogeneity of the impact on female entrepreneurs. Specifically, following Cong, Yang, and Zhang (2021), we apply a textual analysis method to identify the e-commerce-related enterprise and the non-e-commerce counterpart for all industries. Then, we examine the impact of e-commerce expansion on female startup decisions of these two types. The results are reported in two panels of Table 3. Panel A shows that the demand expansion shock significantly facilitates women's creation of businesses involved in e-commerce, both at extensive and intensive margins. In contrast, Panel B reports that female entrepreneurial activity in the non-e-commerce category is insignificant. 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 that there is no significant increase in the proportion of females.

Table 3 here

Similarly, we find that e-commerce expansion increases the proportion of female executives among newly established firms using e-commerce, as shown in Table 4. Panel

A shows that the proportion of female executives in new firms has been improved significantly by e-commerce expansion.

Table 4 here

4.3. Channels

In this subsection, we examine several potential channels through which e-commerce expansion can promote female entrepreneurship, particularly by engaging in e-commerce-related business activities. First, e-commerce may promote female entrepreneurship by lowering the entry barriers to female entrepreneurship. Cong et al. (2021) document that the demand expansion of e-commerce lowers the capital barrier to entry. The reason for this is that, on the one hand, the demand expansion of e-commerce also increases the diversity of demand, which 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 storage rent, employment, and multi-level distributors is lower than that of enterprises operating offline. Moreover, it has been found that women usually face financial constraints when starting a business (Verheul & Thurik, 2001; Sauer & Wilson, 2016). Therefore, women are more likely to enter the informal sector with relatively low initial capital requirements and can use e-commerce to lower the entry barrier.

The business registered capital was not explicitly asked in the OSOME survey, while we plot Figure 2 to indicate that the scale of female-owned e-commerce businesses, measured by the number of full-time employees, is significantly lower than that of female non-e-commerce businesses.

Figure 2 here

In addition, we use the 2018 baseline survey data from ESIEC and match the registered capital from the business registration dataset. Figure 3 shows that there is a negative correlation between the lower 5% quantile level of registered capital and the share of online sales for female entrepreneurs but not male entrepreneurs. This implies that the threshold of registered capital among female MSME owners tends to decrease as the share of e-commerce adoption increases.

Figure 3 here

Similarly, in Figure 4, using the median level of registered capital as a robustness test, we 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 business breaks the spatial distance limit and has a larger market size on the Internet, the expected benefit of engaging in e-commerce can be higher for a given firm scale. This could serve as a potential motivation for female entrepreneurs to engage in e-commerce business activities. Nevertheless, competition among enterprises on e-commerce platforms has been more intense, which could, in turn, reduce expected returns. However, female entrepreneurs engaging more in the informal sector face equally fierce competition in the offline market, which is relatively limited in size.

Figure 4 here

Besides, there is also a negative correlation between the self-reported number of initial employment when venturing and the share of online sales for female entrepreneurs, but not for male entrepreneurs, as shown in Figure 5 by the ESIEC 2018 baseline survey.

Figure 5 here

Secondly, another advantage of engaging in e-commerce for females is the flexibility. It has been noted that women value flexibility in their career choices, such as a preference for part-time work (Booth & Van Ours, 2008, 2013). Le Barbanchon et al. (2021) and Meekes and Hassink (2022) also found that women's preference for flexibility led to shorter work hours and commuting distances in their new jobs. One reason reported for the continuing decline in female labor force participation in China is the need for women to take more care of their families (Ke et al., 2012). Some reports also note that the proportion of "full-time mothers" in China continues to rise.[14] One of the characteristics of e-commerce is the greater flexibility in terms of workplace and time. In terms of the 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 simultaneously. The Internet (especially mobile Internet) has also broken the traditional time limit of sales so that practitioners can efficiently complete related work at any time and with ease. Therefore, e-commerce can help women balance family care and work careers simultaneously, making it more

[14] According to "*2019 White Paper on Chinese Families' Pregnancy and Parenting Styles*," the proportion of full-time mothers among the "post-95" cohort 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.

attractive for females who have entrepreneurial potential but are constrained by housework.

Based on this, we examine the OSOME data in the first quarter of 2022, which includes a section on family care and subjective attitude in the questionnaire. After excluding the sample of MSMEs 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 valid questionnaires were collected. Figure 6 shows the average weekly time (hours per week, including 5 working days and 2 days of weekend) MSMEs spend on running their business and housework, separately by whether they are registered as Taobao sellers and their gender. In terms of business, the time spent by male entrepreneurs is significantly higher than that of females, especially among Taobao sellers. Regarding handling housework, on average, women devoted more time, but there was no significant difference with males at a 95% significance level, and the difference was more pronounced among Taobao registered sellers.

Figure 6 here

We further control for business and owner-level characteristics (age of the firm, age of the owner, business type, number of full-time employees, quarterly revenues, etc.) as well as city and industry-level fixed effects and two-way fixed effects for the regression analysis. Table 5 presents the result, where Columns (1)-(2) use the valid sample. It is consistent with Figure 10 that female entrepreneurs devote less time to business and more time to housework, and more importantly, female businesses engaged in e-commerce operations significantly devote more time to housework, with an increase of about 30.7% compared to the average level. This result suggests that e-commerce allows female entrepreneurs to balance businesses and household tasks more flexibly. The sample is

further restricted to married MSME owners in columns (3) and (4). The result remains robust, and the magnitude of coefficient estimates is relatively larger. Therefore, the flexibility of e-commerce is also an important mechanism for promoting female entrepreneurship and greater engagement in e-commerce businesses.

Table 5 here

Third, we also examine the greatest difficulties female Taobao sellers face in digital transformation or upgrading. The OSOME survey adds the question "What are the greatest difficulties you encountered in using digital technologies to run your business or in the process of digital transformation?" to the questionnaire in the second quarter of 2021 (up to two choices). In line with the previous analysis, the sample was limited to businesses established in 2019 or earlier, and in cities without local outbreaks in that quarter to avoid the impact of COVID-19. The results are shown in Table 6. External factors (especially high cost of usage and maintenance and infrastructure) are the main difficulties for female non-e-commerce businesses, as well as greater concern about the risks associated with digital transformations. Female e-commerce business owners, on the other hand, were most concerned about the cost among external factors but less concerned about the difficulties posed by infrastructure, reflecting to some extent that the relatively lower infrastructure requirement of e-commerce is more favorable for female entrepreneurs who are at a disadvantage of digital technology acquisition. At the same time, female e-commerce business owners also reported that they lacked sufficient time and energy to learn how to use the digital technology, coinciding with the fact that family care and e-commerce businesses have already taken up most of their time.

Table 6 here

4.4. Female's Welfare

Are female entrepreneurs forced or voluntary to start their businesses online? Do they get more benefit through the entrepreneurial activity? To examine the welfare implication, we use the OSOME survey in the fourth quarter of 2021 to text both the entrepreneur's subjective wellness and the profit. As shown in Figure 7, entrepreneurs adopting online businesses (e-commerce) reported higher life satisfaction than employees and offline business owners, indicating that they are not forced to start businesses online, although they report lower profit margins than their male counterparts. Besides, E-commerce also helps maintain a relatively higher profit margin for female entrepreneurs than totally offline businesses.

Figure 7 here

Besides, more women working as business owners can affect their intrahousehold bargaining power. We first compare MSME employees and owners, finding that female entrepreneurs gain marginally more bargaining power in family financial management and investment, but no significant improvement in fertility decisions (Figure 8).

Figure 8 here

Within entrepreneurs, when comparing couple businesses (defined as the spouse of the respondent participates in business operation) and non-couple businesses, we find in

Figure 9 that female entrepreneurs in non-couple businesses gain more bargaining power of both financial issue and others like fertility and work or study plan.

Figure 9 here

5. Women's Resilience throughout the COVID-19 Pandemic

Finally, we use the localized COVID-19 pandemic and lockdowns as an exogenous shock to estimate the female entrepreneur's resilience with digital technology empowerment. Specifically, by matching the OSOME survey data with the sporadic outbreak of COVID-19 and resultant restrictions at the city level, we examine how female entrepreneurs in China use e-commerce and other digital technologies to deal with the restrictions. To this end, we adopt the following difference-in-differences identification strategy for female and male MSMEs, respectively:

$$Y_{ijcq}=\beta\times(COVID\times After)_{cyq}+\mathbf{x}_i^{'}\theta+FEs+\varepsilon_{ijcq} \quad , \qquad (4)$$

where the subscript indicates that business owner *i* in industry *j* in city *c* was surveyed in quarter *q of* year *y.* The key explanatory variable is $(COVID\times After)_{cyq}$, which equals one if a business is located in a city that was subject to local lockdown prior to the survey and zero otherwise. The control variables include firm age, owner's age and gender, business registration type (incorporation, registered self-employed, and unregistered self-employed), employment, and quarterly revenue. The regression also controls for corresponding fixed effects. The results of the regressions using the fixed effects logit model remain robust.

Table 7 first reports the estimation results concerning online operations (e.g., online advertisement, promotion, recommendation, design, etc.) and sales. The dependent

variable in Column (1) is a dummy variable, indicating that a firm has online operations. The dependent variables in Columns (2) and (3) are restricted to combining online with offline and online operations only, respectively. The dependent variable in Column (4) is a dummy for online sales. Column (5) indicates the online promotion (e.g., short videos, live streaming). Panel A includes the female business owners, while Panel B covers the males. As shown in Panel A, localized sporadic outbreaks and lockdowns significantly increase the proportion of female MSME owners adopting online operations and sales. Specifically, compared to the average proportion of female-owned micro and small businesses who operated online (44.5%), the percentage of women adopting online businesses increased by 17.1% after the outbreak, especially for the pure online businesses, which increased by about 27.2% compared to the average. This finding suggests that female entrepreneurs are making better use of online operations to improve their operations and to respond to restrictions. Also, the results in column (4) show that female entrepreneurs 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. In addition, the result in column (5) indicates that female entrepreneurs are more likely to adopt online marketing tools such as short videos and live-streaming, which is about 18.9% higher than the average level. In contrast, the results of the regression for males in Panel B show that the coefficient estimates are relatively small and insignificant for neither forms of online operations nor online sales. The two groups are relatively close in the average level of explained variables. However, in response to localized sporadic outbreaks, females significantly adopt more e-commerce and online operations to cope with the shock than males, implying not only the resilience of female entrepreneurs in the face of crises, but also the empowering effect of digital technologies on females.

Table 7 here

Table 8 further reports the impact of exposure to lockdowns on the adoption of remote work and electronic information systems. These questions were not included in the questionnaire until the fourth quarter of 2020, so we dropped the first wave of OSOME from the sample. The results in column (1) show that both female and male entrepreneurs adopted remote work more after the local outbreak, with an increase of about 30.9% and 16.4% relative to the average level, respectively. In addition, regarding the adoption of electronic information systems, female MSMEs also significantly introduced more sales-related systems, with an increase of 20.0%, consistent with the increased adoption of online business and online sales in Table 7. For other electronic information systems, we did not find that female or male business owners introduced more after the local COVID-19 pandemic outbreak.

Table 8 here

6. Conclusion

By combining administrative business registration data, JD.com 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 JD.com 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. 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.

Developing 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 by e-commerce can synergize with

improvements in gender equality issues. Second, while there are some criticisms of 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, warehousing, and logistics. E-commerce may be more challenging to scale up in other developing countries 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, this paper's findings may underestimate the 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 a lack of data. However, 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. At the same time, guaranteeing 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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Tables

Table 1 Impact of E-Commerce Expansion on Female Entrepreneurship

	(1)	(2)	(3)
	Entrepreneurs (legal representatives) of new entrants:		
	Is there a female	Number of female (log)	Percentage of female
E-Commerce Index	-0.008	0.678***	0.038**
	(0.031)	(0.185)	(0.017)
Control variables	Yes	Yes	Yes
County FE	Yes	Yes	Yes
Industry FE	Yes	Yes	Yes
County-Industry FE	Yes	Yes	Yes
Quarterly FE	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 at the district or county levels are reported in parentheses. The explanatory variable "e-commerce index" is the sales on the JD.com 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: JD.com E-commerce Transaction Data, SAIC Business Registration Data.

Table 2 Impact of E-Commerce Expansion on Female Executives

	(1)	(2)	(3)
	Executives (non-legal representatives) of newly entrants:		
	Is there a female	Number of female (log)	Percentage of female
E-Commerce Index	0.115*	0.429***	0.048***
	(0.067)	(0.126)	(0.018)
Control variables	Yes	Yes	Yes
County FE	Yes	Yes	Yes
Industry FE	Yes	Yes	Yes
County-Industry FE	Yes	Yes	Yes
Quarterly FE	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 JD.com 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: JD.com E-commerce Transaction Data, SAIC Business Registration Data.

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

	(1)	(2)	(3)
	Entrepreneurs (legal representatives) of newly entrants:		
	Is there a female	Number of female (log)	Percentage of female
Panel A: E-Commerce Related Businesses			
E-Commerce Index	0.031***	0.117***	0.032***
	(0.010)	(0.047)	(0.012)
adj. R-sq	0.066	0.261	0.471
Panel B: Non-e-commerce related companies			
E-Commerce Index	-0.009	0.332***	0.490
	(0.031)	(0.125)	(0.355)
adj. R-sq	0.001	0.436	0.128
Control variables	Yes	Yes	Yes
County FE	Yes	Yes	Yes
Industry FE	Yes	Yes	Yes
County-Industry FE	Yes	Yes	Yes
Quarterly FE	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 JD.com 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. The classification of "e-commerce-related" enterprises is calculated by Cong, Yang, and Zhang (2021).

Significance levels: * p<0.1 ** p<0.05 *** p<0.01

Data source: JD.com E-commerce Transaction Data, SAIC Business Registration Data.

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

	(1)	(2)	(3)
	Executives (non-legal representatives) of new entrants:		
	Is there a female	Number of female (log)	Percentage of female
Panel A: E-commerce			
E-Commerce Index	0.014	0.056*	0.012*
	(0.010)	(0.031)	(0.007)
adj. R-sq	0.071	0.079	0.052
Panel B: Non-e-commerce			
E-Commerce Index	0.019	0.204***	0.267
	(0.033)	(0.075)	(0.198)
adj. R-sq	0.005	0.225	0.040
Control variables	Yes	Yes	Yes
County FE	Yes	Yes	Yes
Industry FE	Yes	Yes	Yes
County-Industry FE	Yes	Yes	Yes
Quarterly FE	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 JD.com platform in the sample counties (logarithmically). The explanatory variables are the dummy variables 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. The classification of "e-commerce-related" enterprises is calculated by Cong, Yang, and Zhang (2021).

Significance levels: * p<0.1 ** p<0.05 *** p<0.01

Data source: JD.com E-commerce Transaction Data, SAIC Business Registration Data.

Table 5 Business and Family Care Time Spending of Entrepreneurs

	(1)	(2)	(3)	(4)
	Full sample of topics		Married Sample	
	Operation	Housekeeping	Operation	Housekeeping
Female operators × Taobao sellers	2.940	8.584*	3.491	9.644*
	(5.947)	(4.362)	(7.135)	(5.476)
Female operators	-8.888***	3.005***	-8.112***	3.159***
	(1.344)	(1.023)	(1.596)	(1.156)
Taobao sellers	-0.928	0.036	-2.897	-2.219
	(2.491)	(1.814)	(3.042)	(1.999)
adj. R-sq	0.063	0.009	0.052	0.005
Controls	Yes	Yes	Yes	Yes
City FE	Yes	Yes	Yes	Yes
Industry FE	Yes	Yes	Yes	Yes
City-Industry FE	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 2022Q1.

Table 6 Top Difficulties of Female Entrepreneurs in Digital Transformation or Upgrading

	(1)	(2)	(3)	(4)
	The most important difficulties encountered in digital transformation or upgrading such as e-commerce			
Panel A: Subjective Factors	Subjective factors	Time	Usage	Risk
Female operators × Taobao sellers	0.077	0.118**	-0.030	0.060
	(0.063)	(0.058)	(0.045)	(0.055)
Female operators	-0.021	-0.073***	-0.011	0.059***
	(0.015)	(0.014)	(0.011)	(0.012)
Taobao sellers	-0.018	-0.010	0.007	-0.028*
	(0.025)	(0.023)	(0.023)	(0.017)
adj. R-sq	0.016	0.032	0.020	0.009
Panel B: External factors	External Factors	Higher cost	Funds	Infrastructure
Female operators × Taobao sellers	-0.013	-0.006	0.067	-0.063***
	(0.052)	(0.058)	(0.048)	(0.020)
Female operators	0.053***	0.058***	0.004	0.014*
	(0.013)	(0.014)	(0.011)	(0.007)
Taobao sellers	0.045*	0.059***	-0.006	-0.007
	(0.023)	(0.022)	(0.019)	(0.012)
adj. R-sq	0.049	0.021	0.030	0.006
Controls	Yes	Yes	Yes	Yes
City FE	Yes	Yes	Yes	Yes
Industry FE	Yes	Yes	Yes	Yes
City-Industry FE	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 2021Q2.

Table 7 Impact of Local Outbreak on Online Operations and Sales, by Gender

	(1)	(2)	(3)	(4)	(5)
	Online business			Online Sales	Online Marketing
	Any form	Combination	Online only		
Panel A: Female Operators					
COVID × After	0.076***	0.045*	0.031*	0.073***	0.046**
	(0.027)	(0.024)	(0.016)	(0.024)	(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 × After	0.009	0.006	0.003	0.002	-0.003
	(0.012)	(0.013)	(0.007)	(0.011)	(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		
Controls	Yes	Yes	Yes	Yes	Yes
Quarterly FE	Yes	Yes	Yes	Yes	Yes
City FE	Yes	Yes	Yes	Yes	Yes
Industry FE	Yes	Yes	Yes	Yes	Yes
City-Industry FE	Yes	Yes	Yes	Yes	Yes
City-Annual FE	Yes	Yes	Yes	Yes	Yes
Industry-Year FE	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 × 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 8 Impact of Local Outbreak on Remote Work and Electronic Information Systems, by Gender

	(1)	(2)	(3)	(4)	(5)	(6)
	Remote work	Electronic information systems				
		Sales	Finance	Payments	Management	Production
Panel A: Female Operators						
COVID × After	0.034*	0.030**	-0.023	-0.029	-0.009	0.003
	(0.020)	(0.014)	(0.016)	(0.024)	(0.016)	(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 × After	0.019**	0.010	0.008	0.012	0.006	0.006
	(0.009)	(0.008)	(0.011)	(0.015)	(0.012)	(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					
Controls	Yes	Yes	Yes	Yes	Yes	Yes
Quarterly FE	Yes	Yes	Yes	Yes	Yes	Yes
City FE	Yes	Yes	Yes	Yes	Yes	Yes
Industry FE	Yes	Yes	Yes	Yes	Yes	Yes
City-Industry FE	Yes	Yes	Yes	Yes	Yes	Yes
City-Annual FE	Yes	Yes	Yes	Yes	Yes	Yes
Industry-Year FE	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 × 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.

Figures

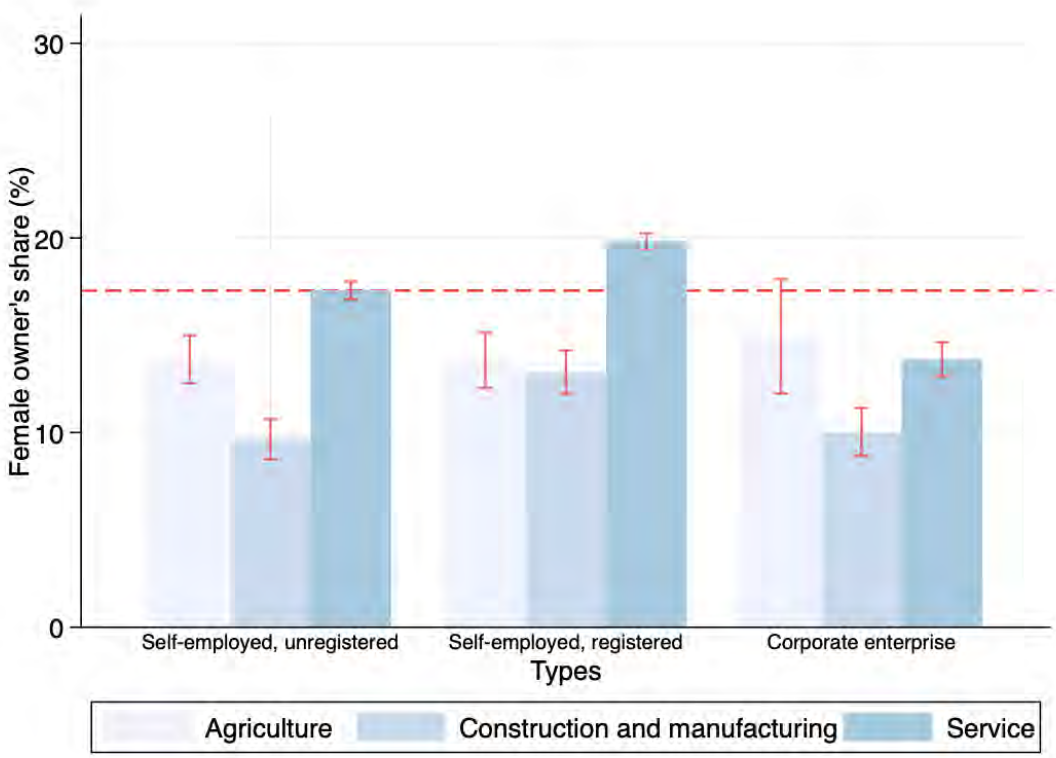

Figure 1 Share of Female Entrepreneurs in Different Industries and Registration Types in the OSOME Survey

Note: The reported share is the proportion of female MSME respondents (%), and the vertical line indicates the 95% confidence interval. The horizontal line indicates the full sample average.
Data source: OSOME, 2020Q3 to 2021Q4.

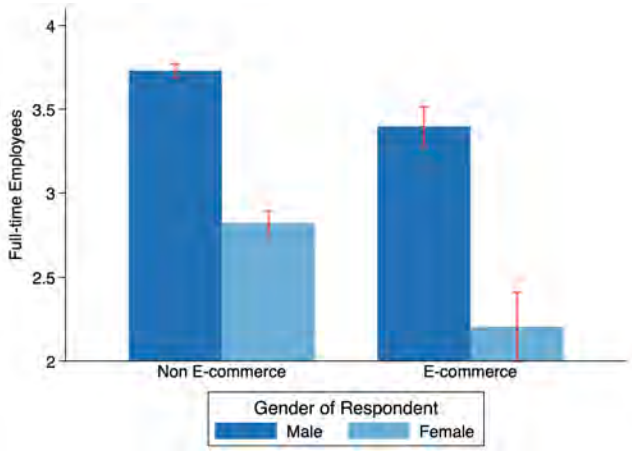

Figure 2 Average Number of Full-time Employees, by Gender and E-commerce

Note: The figure reports the average number of full-time employees. The horizontal line indicates the full sample average.

Data source: OSOME, 2020Q3 to 2021Q4.

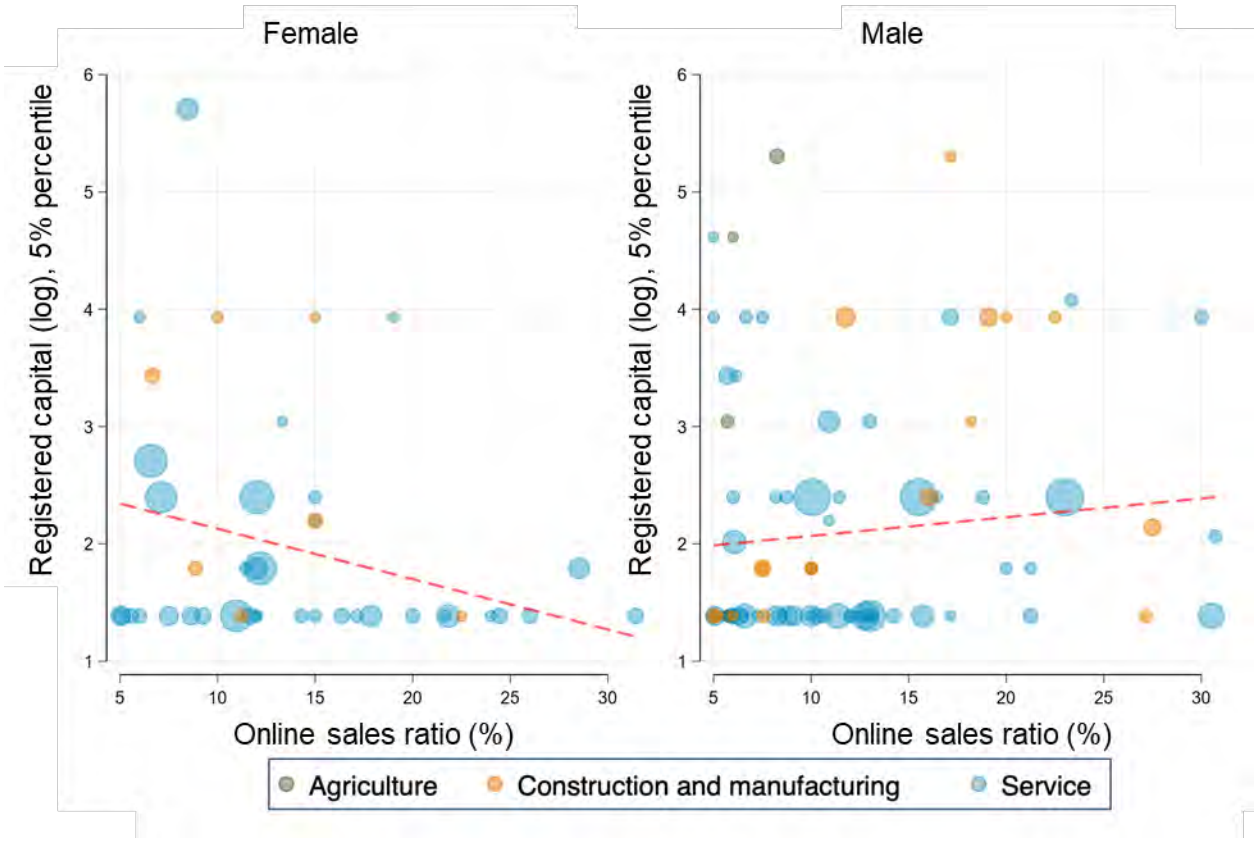

Figure 3 Lower 5% quartile level of the registered capital versus the share of online sales, by gender

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

Data source: ESIEC 2018.

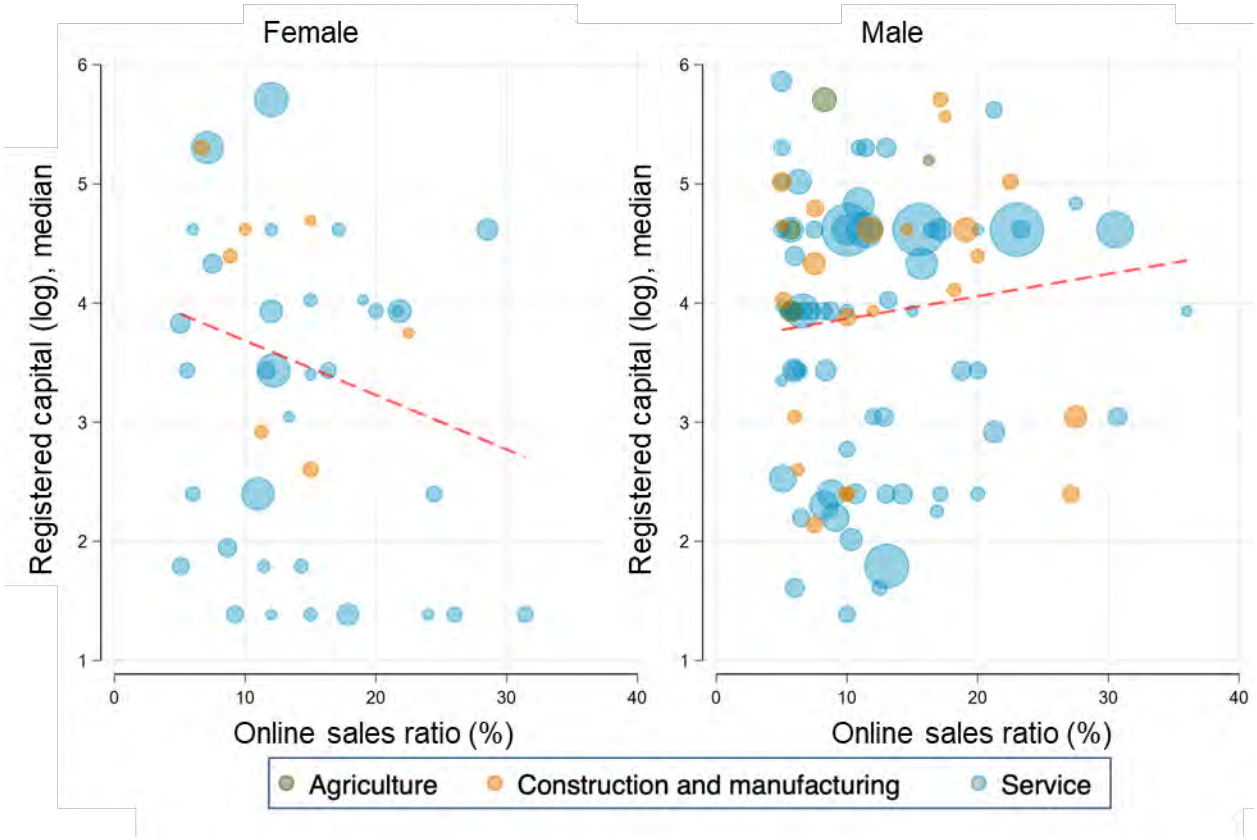

Figure 4 Median level of the registered capital versus the share of online sales, by gender

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

Data source: ESIEC 2018.

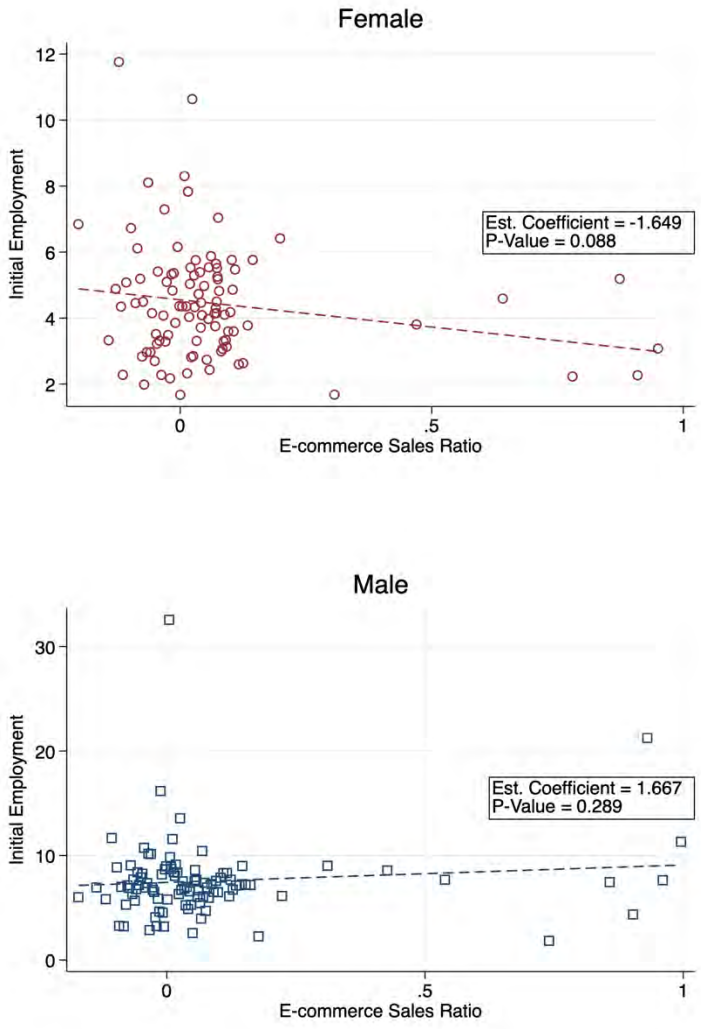

Figure 5 Initial Employment and Share of Online Sales for Entrepreneurs, by Gender

Note: Controlled for firm characteristics, 1-digit industry FE, and city FE.
Data source: ESIEC 2018.

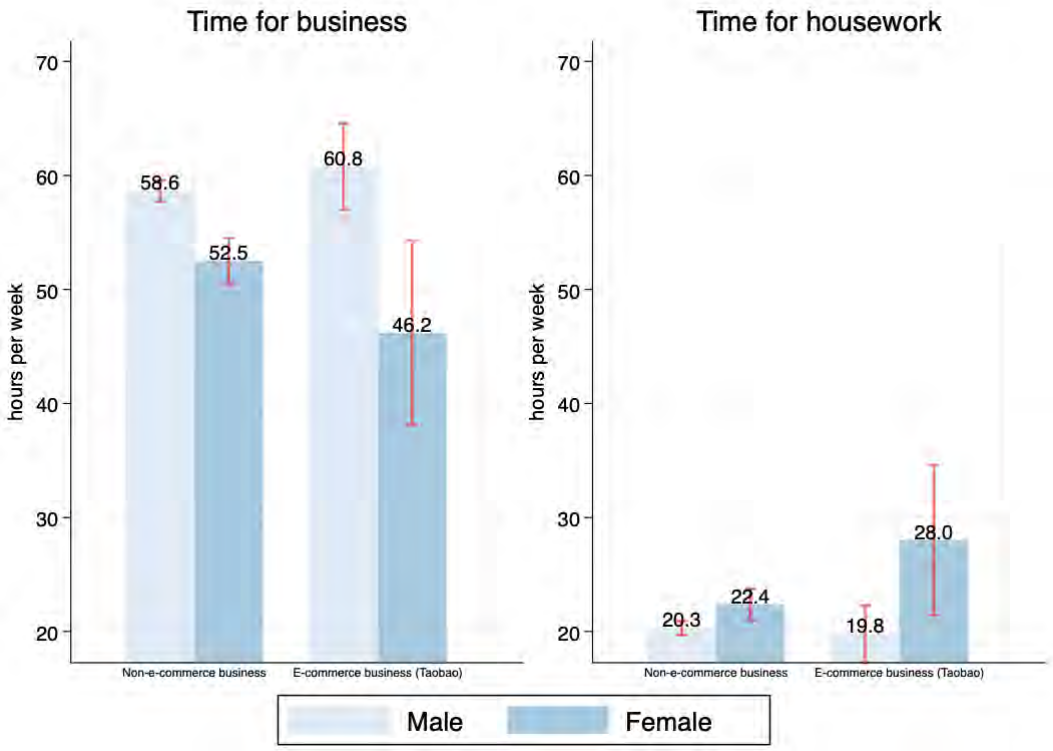

Figure 6 Average Weekly Time Spending by Entrepreneurship

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.

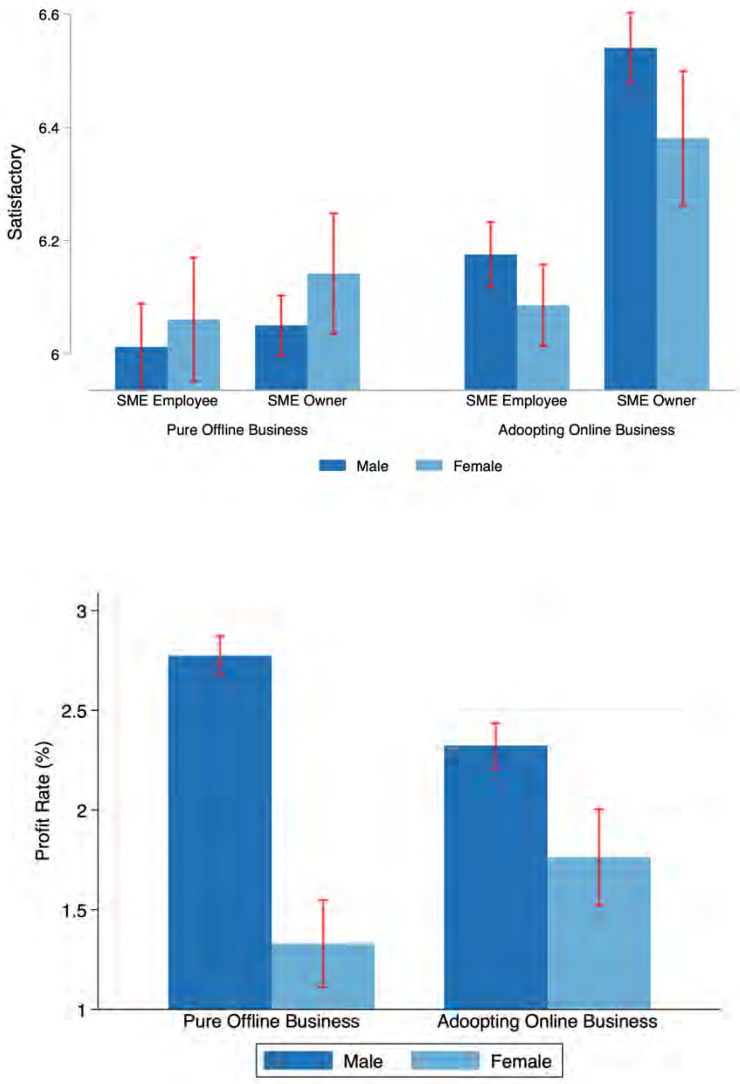

Figure 7 Entrepreneurs' subjective life satisfaction and Profit Margin

Note: Regression coefficients on the interaction terms b/w female and e-commerce, controlling for other characteristics and FEs, are significant.

Data source: OSOME 2021Q4.

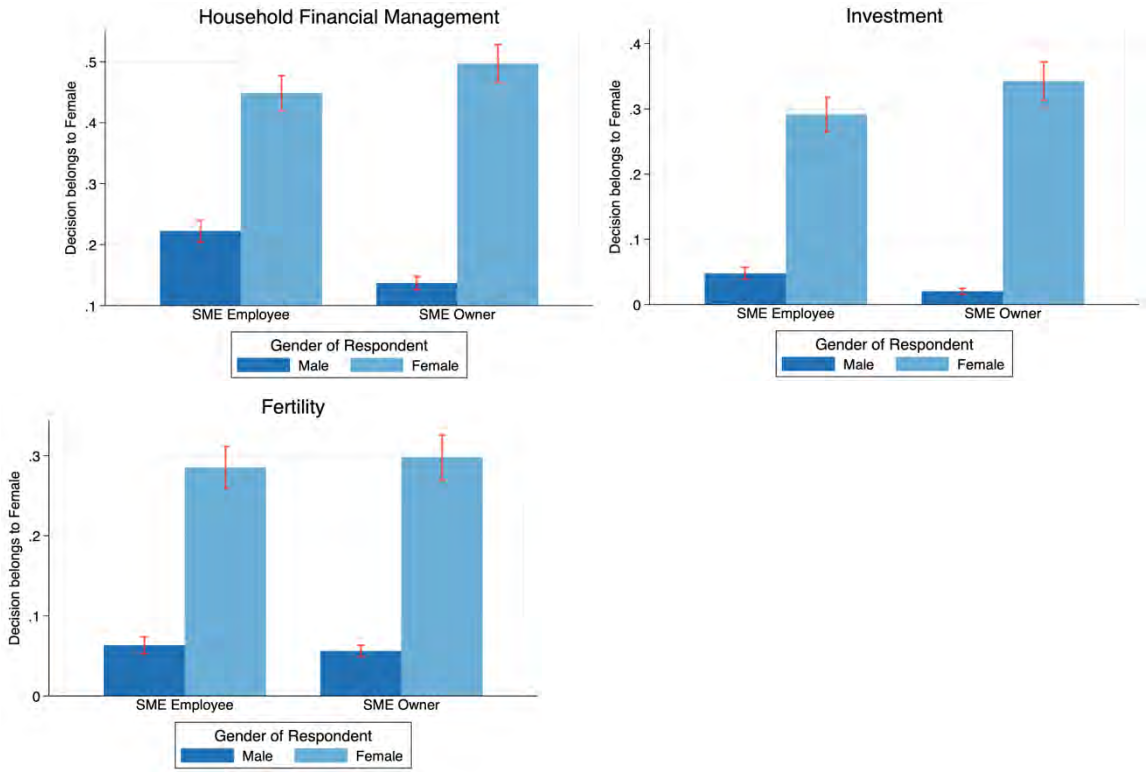

Figure 8 Female's Intrahousehold Bargaining Power, Comparing MSME Employees and Owners and by Gender

Data source: OSOME 2022Q1.

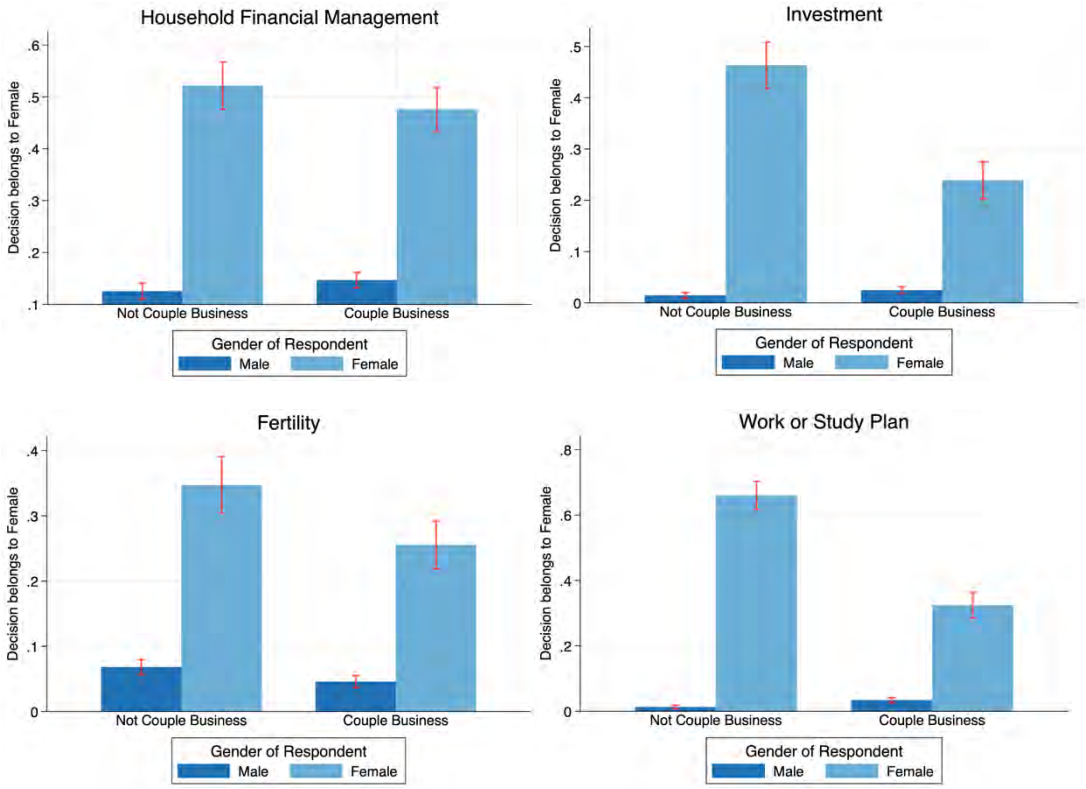

Figure 9 Female's Intrahousehold Bargaining Power, Comparing Couple and Non-couple Businesses and by Gender

Data source: OSOME 2022Q1.

Appendix A: Textual Analysis Algorithm to Predict Gender

The paper restricts to samples using Chinese names in business registration data and uses a plain Bayesian model to predict their gender.[15] For text processing, since Chinese surnames are relatively fixed (including compound surnames which contain more than one characters), 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.[16] 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 provides the gender prediction model trained based on the public records of the network, in addition to the 1% sampling data of the population census which contains the required information. The results are generally

[15] Due 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.

[16] The 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/c_1211176092.htm For a related report, see.
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.

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*" (*better than male*) and "*Ruonan*" (*just like male*) are mostly used for female names, which carry the expectation of the elders that their daughters will not be inferior to men. "*Yanan*" (the next is male) and "*Zhaodi*" (want a male) 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." (*better, successful*) Meanwhile, when "*Nan*"(*male*) 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.

Appendix B: Descriptive Fact 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 Appendix Figure A1 shows.

As shown in Appendix Figure A1, the proportion of female entrepreneurs, as measured by legal representatives, increases from 16.4% in 1995 to 27.6%, consistent with Wang (2020). According to the World Bank, China's female labor force participation rate declined from 71.8% to 61.8% between 1995 and 2020,[17] 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 and Liao (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.

[17] Data 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).

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 Appendix Figure A2. 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.

A similar trend is reflected in the proportion of female executives in Appendix Figure A3. 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 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.

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.[18] 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.[19]

[18] The 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.

[19] Refer 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.

Appendix C: Spillover effects

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 & 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.

Appendix Figure A4 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.

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 Appendix Figure A5. 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 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.

Appendix Table A1 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, indicates 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.

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 Appendix Figure A6), 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 extensive margin, but also increases the overall welfare protection of employees at the intensive margin.

Appendix Tables

Table A1 Balance Check of JD.com Sample

	Sampled	Non-sampled	Unconditional Diff.	Conditional Diff.
per capita GDP (log)	10.566	10.294	0.272***	-0.045
Population density	0.087	0.031	0.057***	-0.006
Fiscal self-sufficiency rate	3.558	5.303	-1.745***	0.153
Fixed asset investment (log)	14.445	13.751	0.693***	-0.055
Region area (log)	7.726	7.695	0.031	-0.296***
Obs.	214	1,882		

Note: The conditional difference controls for province FE, rural dummy, and the interaction term.
Data source: China Regional Statistical Yearbook.

Table A2 Balance Check of *JDBang* Counties

	JDBang	Non-JDBang	Unconditional Diff.	Conditional Diff.
Panel A: Controls				
per capita GDP (log)	10.283	10.968	0.686***	-0.149
Population density	0.050	0.157	0.107***	-0.037
Fiscal self-sufficiency rate	4.382	2.292	-2.089***	0.041
Fixed asset investment (log)	14.169	15.865	1.696***	0.040
Region area (log)	7.582	7.896	0.314*	-0.249
Panel B: Other Characteristics				
Teacher-student ratio (per 10,000 students)	718.694	680.745	-37.949**	-0.183
Number of mobile phone users (log)	5.850	6.505	0.655***	-0.145
Number of Internet users (log)	3.950	4.756	0.805***	-0.074
Total retail sales of consumer goods (log)	13.031	13.821	0.790***	0.129
Obs.	115	99		

Note: The conditional difference in Panel A controls for province FE, rural dummy, and the interaction term. The conditional difference in Panel B controls for variables in Panel A, province FE, rural dummy, and the interaction term.
Data source: China Regional Statistical Yearbook.

Table A3 Employees of Female Entrepreneurs

	(1) Number of employees	(2) Number of female employees	(3) Percentage of female employees
Female operators × Taobao sellers	0.352*	0.205*	0.033**
	(0.198)	(0.121)	(0.014)
Female operators	-0.462***	0.132***	0.120***
	(0.051)	(0.029)	(0.004)
Taobao sellers	-0.758***	-0.216***	0.000
	(0.109)	(0.065)	(0.006)
adj. R-sq	0.150	0.071	0.039
Control variables	Yes	Yes	Yes
Quarterly, city and industry FEs	Yes	Yes	Yes
Two-way FEs	Yes	Yes	Yes
Quarterly-City-Industry FE	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: OSOME 2020Q3 to 2021Q4.

Appendix Figures

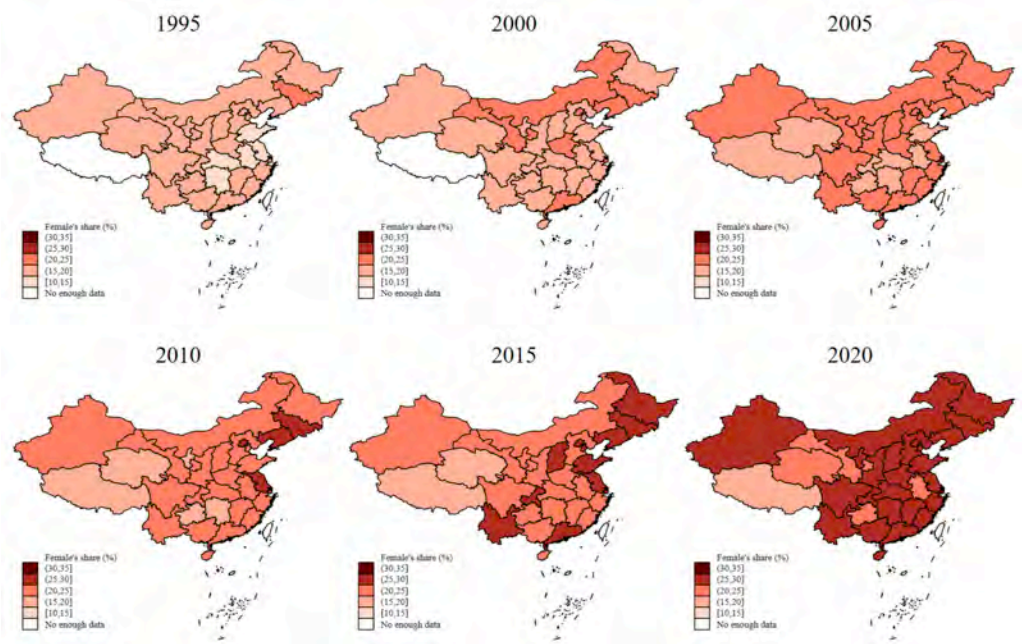

Figure A1 Distribution and Change of the Proportion of New Enterprises with Female Legal Representative in China, 1995-2020

Note: The proportion of female entrepreneurs is calculated based on 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.

Data source: SAIC Business Registration Data.

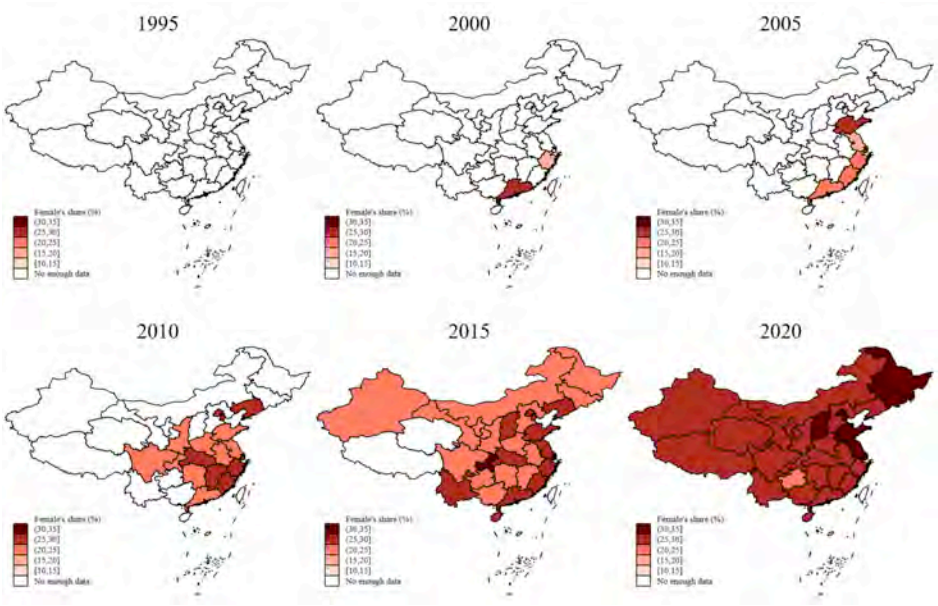

Figure A2 Distribution and Change of the Proportion of Female Entrepreneurs in New E-commerce-related Enterprises in China, 1995-2020

Note: The proportion of female entrepreneurs is calculated based on the 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. The classification of "e-commerce-related" enterprises is calculated by Cong, Yang, and Zhang (2021).

Data source: SAIC Business Registration Data.

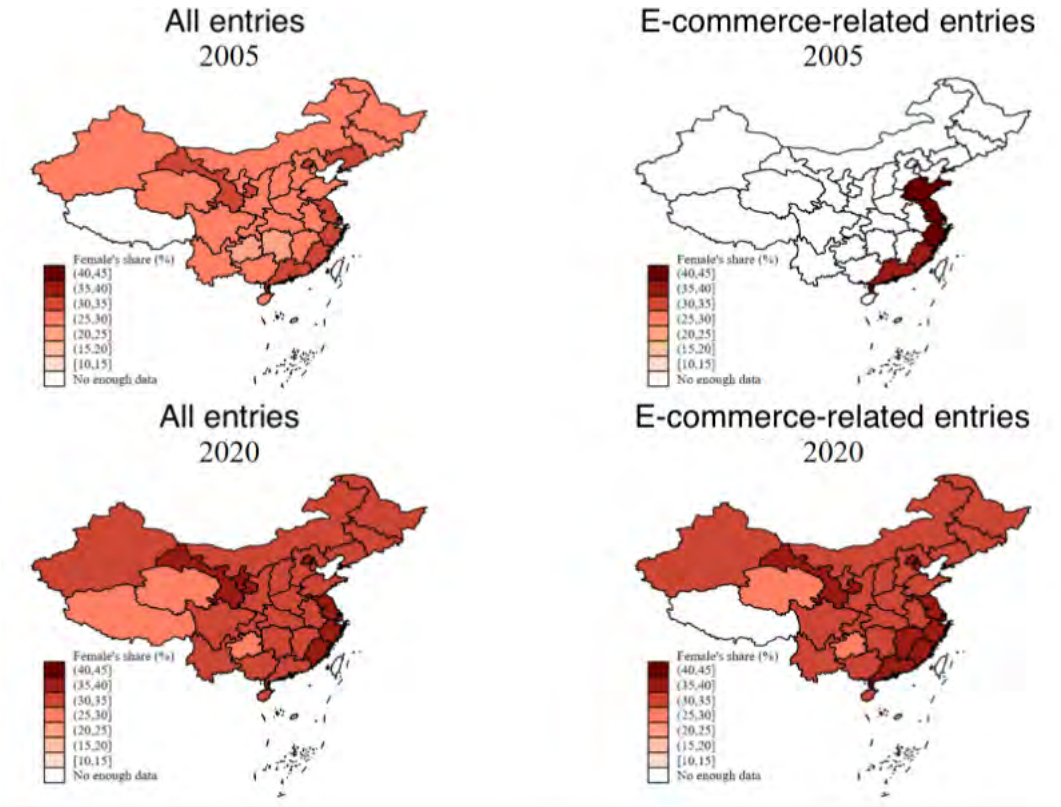

Figure A3 Distribution and Change in the Proportion of Female Executives in New Enterprises (All & E-commerce) in China, 2005-2020

Note: The proportion of female executives is calculated based on the number of executives who are not 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. The classification of "e-commerce-related" enterprises is calculated by Cong, Yang, and Zhang (2021).

Data source: SAIC Business Registration Data.

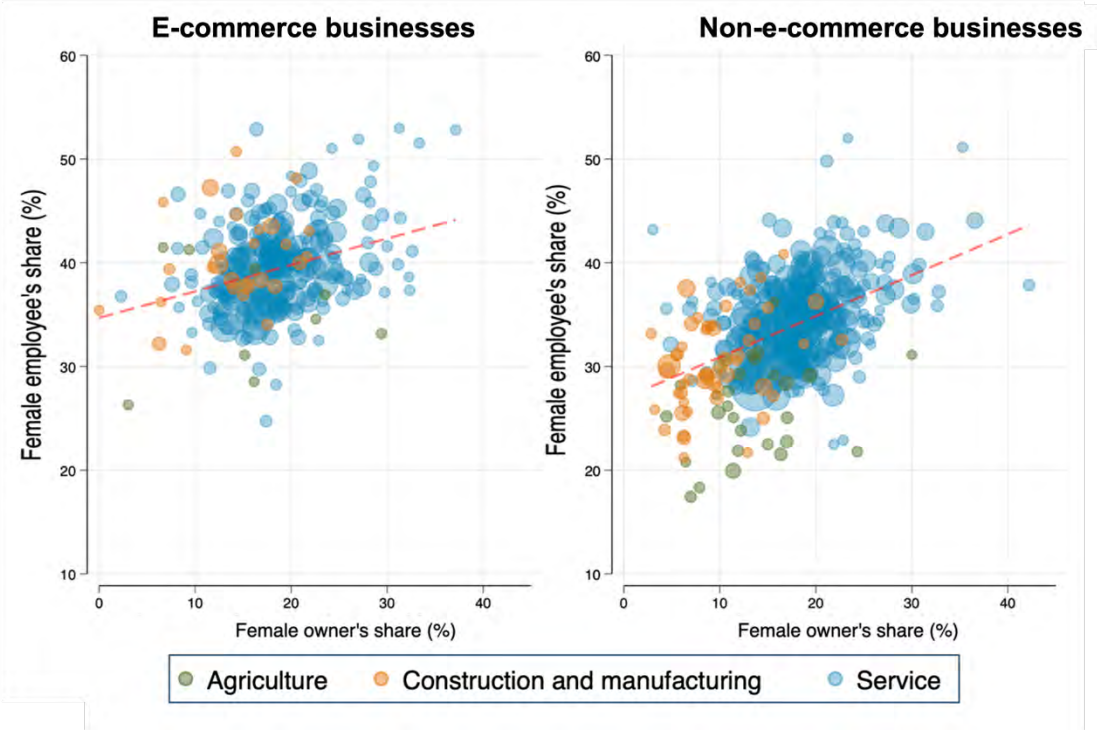

Figure A4 Proportion of female micro and small operators versus female employees, by e-commerce operators versus non-e-commerce operators

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.

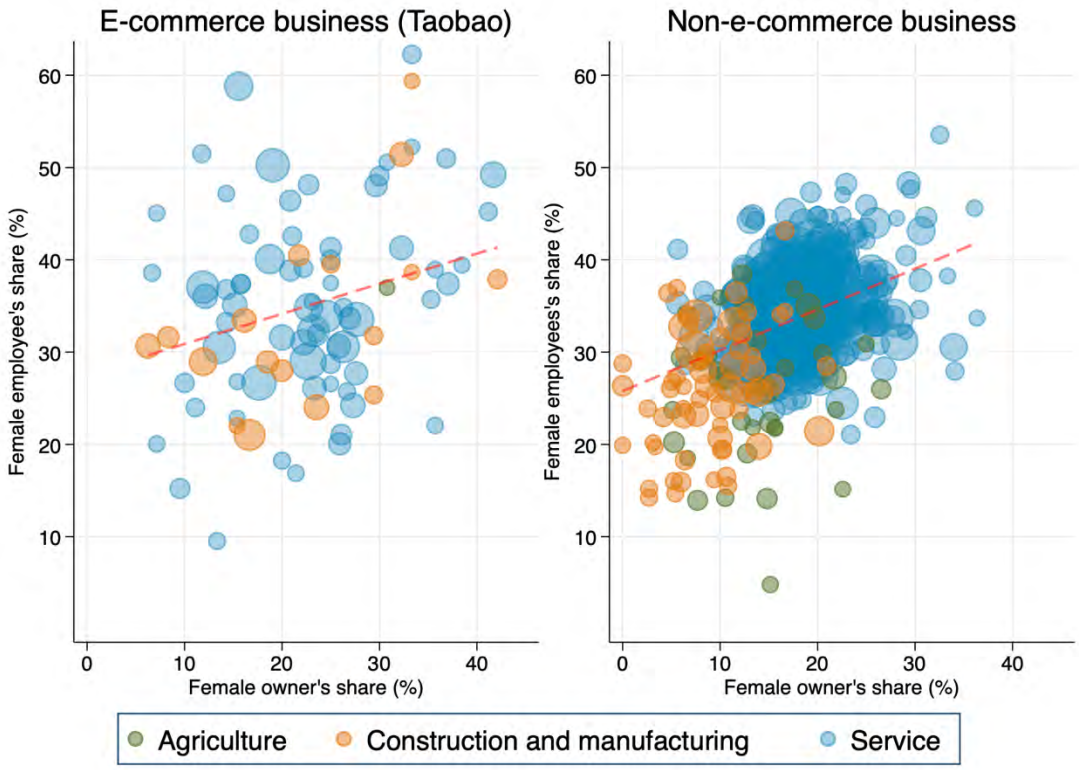

Figure A5 Proportion of female micro and small operators versus female employees (established before 2020), by Taobao merchants and non-Taobao merchants

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.

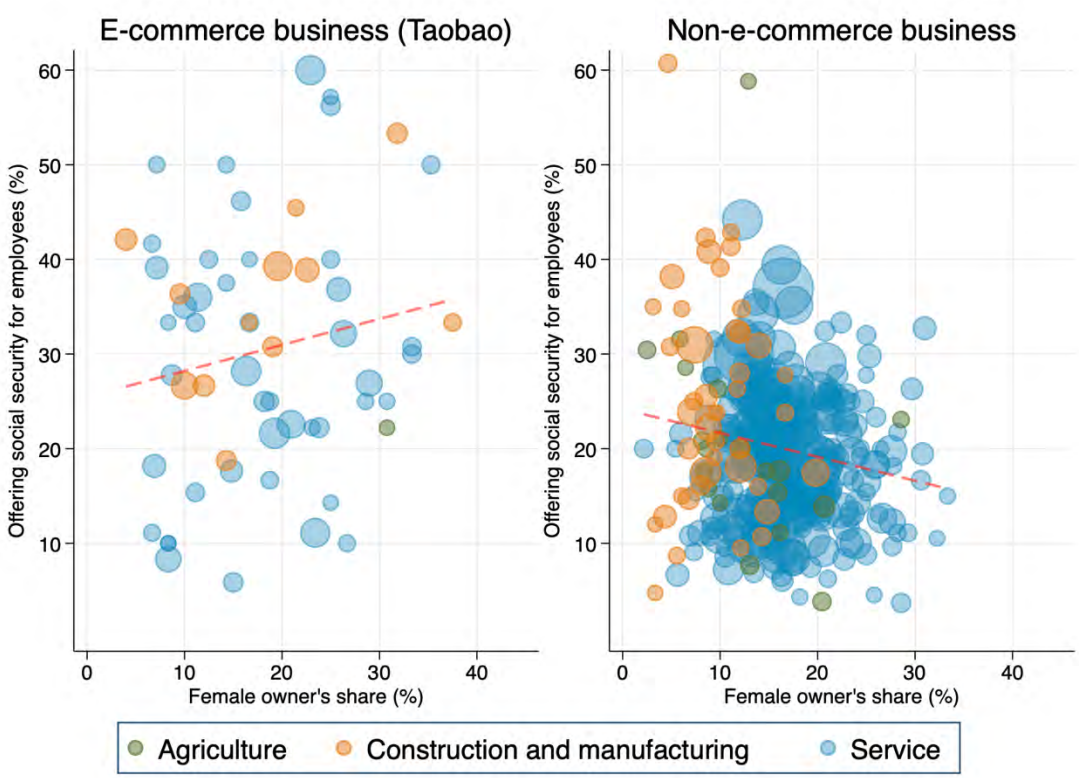

Figure A6 Proportion of female micro and small operators versus full-time employees' social security contributions (established before 2020), the breakdown of Taobao merchants and non-Taobao merchants

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.

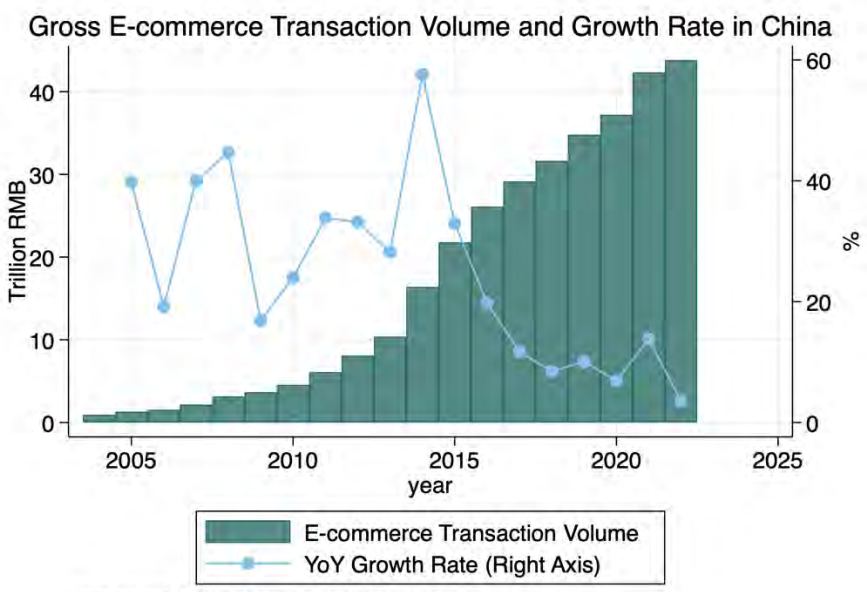

Figure A7 Gross E-commerce Transaction Volume and Growth Rate in China

Note: E-commerce transaction volume includes online retails (sales), wholesales, and purchases.

Data source: National Bureau of Statistics of China.