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Influence of E-commerce on Birth Rate: Evidence from Rural China Based on County-Level Longitudinal Data*

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Abstract

Using official data from the Jiangsu region to construct county-level longitudinal samples and econometric models for the period from 2011 to 2019, we investigated the causal relationship between e-commerce development and regional birth rate in rural China. We used two indicators, the presence and number of Taobao villages in a county, to measure the development level of rural e-commerce. We find that e-commerce significantly reduces the crude birth rate (CBR) in most models, although this influence varies between groups. Furthermore, the negative effect of e-commerce is larger in regions with higher ratios of primary industry employment and smaller in well-developed regions. A U-shaped relationship exists between economic development level and CBR. Additionally, CBR is lower in counties with higher population densities and higher in counties with higher ratios of primary sector employment.

Keywords: e-commerce; crude birth rate; Taobao village; rural China; Jiangsu

JEL classification: C23, C26, J13, R10

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1. Introduction

In recent decades, many countries, including China, have experienced a sharp decline in birth rate (Zhang, 2017). For nearly two decades, China's birth rate has been below long-term replacement levels[1] (Zheng, Cai, Wang, and Gu, 2009). The total fertility rate (TFR) decreased from 6.385 in 1965 to 2.309 in 1990 and further to 1.665 in 2015. Crude birth rate (CBR) generally follows the same trend as TFR. Although CBR increased from 20.86 in 1960 to 43.37 in 1963, it decreased from 37.88 in 1965 to 21.06 in 1990 and further to 12.07 in 2015.

China is experiencing aging of the population in the recent period. It has been said that "In China, the population is growing old before getting rich" (*Weifu Xianlao*) (Cai, 2016). Therefore, establishing policies to increase the birth rate has become a priority of the Chinese government. In October 2015, China announced the replacement of its one-child policy with a universal two-child policy from January 1, 2016. According to a meeting of the Political Bureau of the Communist Party of China Central Committee, held on May 31, 2021, China will support couples who wish to have a third child. This is because, in recent years, the problem of an aging population has been steadily increasing[2]. Although the CBR increased from 12.07 in 2015 to 12.95 in 2016, it decreased to 10.48 in 2019 (National Bureau of Statistics of China, 2020). Thus, it is necessary to clarify the factors that can increase the TFR or CBR other than the one-child deregulation population policies.

Related to the decreasing birthrate and aging population is the issue of "hollowing out" of the rural population. Through industrialization and urbanization, the migration of middle- and higher-educated younger generations from rural to urban areas has increased, resulting in the "hollowing out" of the rural population in terms of age structure (Zhang, 2004). To address this issue, the Chinese government may promote the development of rural e-commerce. With the development of rural e-commerce represented by Taobao villages, e-commerce-related jobs may become available for residents in rural areas. According to AliResearch (2017, 2018), Taobao villages alone directly created 1.3 million jobs in 2017 and 1.8 million jobs in 2018. Moreover, the annual sales of online stores in Taobao villages and Taobao towns exceeded 1 trillion RMB, with 2.96 million active online stores and 8.28 million jobs created (AliResearch, 2020). It is predicted that the

[1] Under modern low-mortality conditions that typify China, replacement-level fertility is conventionally defined as a total fertility rate of 2.1 births per woman.
[2] The article is available on Xinhua website. http://www.xinhuanet.com/english/2021-06/01/c_139981452.htm. Accessed on February 10, 2022.

development of rural e-commerce may make more rural residents perform nonagricultural work in rural areas.

The Chinese government has recently announced a priority national policy to expand e-commerce to rural areas to foster rural economic development. Although it is assumed that the change in employment status with the development of e-commerce may affect the fertility behaviors of individuals and households in rural China, empirical studies on this issue are scarce. This study attempted to bridge this gap.

From an economic perspective, e-commerce development may have both positive and negative effects on birth rate. E-commerce may create jobs with higher wages and more flexibility in rural areas and, consequently, reduce rural-urban migration for non-agricultural employees. Therefore, rural residents can remain with their children and parents and have more time to raise their children (a positive effect). In contrast, e-commerce may provide more employment opportunities, including jobs with higher wages for women and young people; therefore, the opportunity costs of having children may increase (negative effect).

Numerous studies have used micro-level data to determine fertility, birth rate, and people's intention to have children (e.g., Zhang, 1990; Zheng et al., 2009). However, empirical studies using macro-level data are scarce (Iwasaki and Kumo, 2019, 2020). In China, population policies vary among provinces (Gu, Wang, Guo, and Zhang, 2007). Furthermore, empirical studies using regional-level data are scarce, although there are a few studies, such as those by Cai (2010). To the best of our knowledge, the relationship between e-commerce development and birth rate in rural China has not yet been examined using county-level data; therefore, this study supplements the existing literature.

This study examines the impact of rural e-commerce on birth rate using county-level panel data to fill this gap in the literature. We adopt the generalized difference-in-differences, fixed-effect model, fixed-effect instrumental variable estimation, and dynamic panel data models using Jiangsu county-level panel data from 2011 to 2019. We used the statistical yearbooks of Jiangsu province to construct the county-level panel data. Jiangsu province was chosen because it is one of the few provinces providing annual CBR data; it has one of the lowest birth rates, and its e-commerce is one of the most developed in China. We found that rural e-commerce reduces CBR, and its effects are heterogeneous among employment structures and economic development standards.

The main contributions of this study are as follows: First, to the best of our knowledge, this is the first study to examine the association between e-commerce and birth rate in

rural China using county-level panel data.[3] We focus on Jiangsu province because it is one of the most developed provinces and its birth rate is one of the lowest in China. As Cai (2010) states, Jiangsu is the forerunner of China's socioeconomic development and economic globalization; what happens there and in other highly developed areas in China are prospective indicators of future development in other provinces. Second, we use county-level panel data to reduce endogeneity issues arising from time-invariant unobserved heterogeneity. County-level data are the smallest units of available macroeconomic data from the Provincial Bureau of Statistics. The county-level data in the statistics yearbook limits the analysis of the association between e-commerce and a few economic indicators (World Bank and Alibaba, 2019); thus, this study is worthwhile. Third, Luo and Niu (2019) used household-level data on rural China and found that e-commerce participation is not random in Taobao villages. It is assumed that e-commerce development in a county is not exogenous because households participating in it differ in many ways from those who do not. To investigate causal relationships, we use the instrumental variable (IV) method to address endogeneity. Fourth, considering the heterogeneity in groups, we divided the sample into regional groups to compare and analyze the interaction between e-commerce and other factors (e.g., employment in the primary sector, income, and GDP).

The remainder of this paper is organized as follows. We review the existing literature in section 2, present the data and methodology in section 3, and discuss the empirical results in section 4. Finally, we conclude the study in section 5.

2. Literature Review

Several studies (e.g., Balbo, Billari, and Mills, 2013; Morgan and Taylor, 2006) have comprehensively examined birth rate. An economic versus cultural dichotomy was identified based on macro-level birth-rate determinants (Billari, 2004). While several studies have investigated how economic trends, social policies, institutional constraints, and welfare regimes influence birth rate, others have focused on the influence of values, attitudes, and cultures on reproductive behaviors. In addition to these two broad approaches, other macro-level studies have examined the role of contraceptives in birth-rate dynamics (Balbo et al., 2013).

[3] A related study is that of Billari et al. (2019), which examined the impact of broadband Internet on birth rates and found positive relationships using German household- and county-level data.

2.1 Economic theory on birth-rate behaviors

Birth rate is a complex phenomenon, and its determinants are difficult to define. It is almost impossible to find a single complete theory on birth rate (Lacalle-Calderon, Perez-Trujillo, and Neira, 2017). Birth rate is influenced by both social and biological factors. Socially, it is linked to numerous socioeconomic and sociocultural factors; biologically, it is dependent on evolutionary antecedents and physiological constraints (McNicoll 1980).

Leibenstein (1957, 1974) was a pioneer in extending the microeconomic analysis. The study found that the number of children declined as income per capita increased. The essence of the model is the presumption that families would balance utility against disutility ascribed to an *n*th child to determine whether a family wanted an *n*th child (Leibenstein, 1957, 1974).

Becker (1960) considered the number of children n and the quality of children q as consumption goods and described a decline in birth rate as a general utility maximization problem. Consumption theory was used to show that secular birth-rate changes and cross-sectional differences in completed family sizes of households in industrialized countries were the result of variations in family income and the cost or opportunity cost of having children. Mincer (1963) showed that women's employment and rising wages tend to discourage childbearing due to increased opportunity costs. Therefore, women's income levels negatively affected the number of children. Butz and Ward (1979) found that an increase in husbands' or household income effectively raised the demand for children. Conversely, an increase in wives' income was found to generate a substitution effect that decreases demand for children (Kato, 2000).

Becker and Lewis (1973) also focused on the quantity–quality tradeoff and found that ignorance of birth control was no longer an explanatory factor. Instead, the relationship between the quantity and quality of children was brought to the fore and explicated.

Easterlin's (1966) relative income hypothesis is frequently cited while considering the impact of the economic environment on birth rate within a country. It was found that when future economic prospects improve, birth rate can be expected to increase.

2.2 Effect of e-commerce on birth rate

From an economic perspective, e-commerce development has positive or negative effects

on the birth rate. To the best of our knowledge, there are no studies on the impact of e-commerce on birth rate. Only one study is related to the issue: using German panel data at both individual (aged 25–45) and county levels; Billari et al. (2019) examined the effects of broadband Internet on fertility and found that broadband Internet positively affects fertility at both individual (highly educated women aged 25–45) and county levels.

Concerning the positive effects, Billari et al. (2019) discussed three potential mechanisms underlying the relationship between Internet use and birth rate: information, marriage, and work-life balance. First, the Internet provides access to information on contraceptives and the possible life-changing consequences of choosing to become a parent. Second, the Internet has been described as a "new social intermediary in the search for mates" (Rosenfeld and Thomas 2012). Bellou (2015) found that the Internet may decrease search costs and increase the rate of partnership offers. Third, high-speed Internet may affect labor-force participation and work-life balance (Wajcman, 2015; Dettling, 2017), thereby enabling individuals to balance work and parenting more easily. This is relevant to e-commerce because it involves buying and selling goods and services over the Internet. Two positive effects have been identified in the literature.

Income effect[4]. E-commerce may create jobs, including those with higher wages and more flexibility, to meet individual demands, such as part-time and home-based jobs, which are often more attractive to women. These employment opportunities fundamentally increase household welfare (World Bank and Alibaba, 2019). Online shop owners who use e-commerce platforms earn higher wages[5]. According to Butz and Ward (1979), husbands earning higher wages raise household income and increase the demand for children. Therefore, those who participate in rural e-commerce can increase their household income while working in villages. This leads to a decrease in the demand for urban migration for nonagricultural income. Thus, with the development of e-commerce

[4] From the micro perspective, regarding the effect of income based on the Becker model (Becker, 1985), in addition to the direct income effect, which may increase the number of children (positive effect), there is also a "price of quality" effect for children with income-level growth, which may decrease the number of children (negative effect). An increase in income is expected to have a positive effect on the fertility of the first child (with the income effect outweighing the price effect), while it may have a negative effect on the third and younger children (with the price effect outweighing the income effect) (Yamaguchi, 2005). Since we use the county-level aggregate data of CBRs that could not distinguish the birth rates by the order of children respectively, we could not investigate the two types of income effects. A detailed analysis of the issue has become our new challenge.

[5] However, using a randomized controlled trial method and survey data, Couture et al. (2021) found little evidence on income gains from e-commerce in rural producers and workers.

in rural areas, more people can stay with their children and parents in their home villages and focus on raising children[6].

Discretionary work systems and greater flexibility in working hours. Online shop owners who use e-commerce platforms can also enjoy flexible work styles while working from home. Flexible work arrangements allow individuals to devote more time to their families. In rural areas of China, e-commerce is not limited to high-tech sectors. It also offers employment opportunities for semi-skilled workers and other groups (including people with disabilities), who have had limited employment opportunities in the past. Therefore, with the development of e-commerce, more people will benefit from flexible work. For example, Yamaguchi (2005) pointed out that family-friendly work environments that offer benefits such as parental leave programs, flexible work time, and telecommuting can reduce the negative effect of women's full-time work on fertility rates compared to that of full-time housewives and part-time working women in Japan. Higuchi and Abe (1999) indicated that family-friendly work environments may reduce the opportunity costs of childbearing and childcare, making it more feasible for married Japanese women to continue working. While the ratio of women-to-men entrepreneurs is one woman for every three men across all business sectors, this ratio is at or near parity on Alibaba e-commerce platforms. Moreover, 75% of rural e-tailers are 20–29 years old (World Bank and Alibaba, 2019). Therefore, it can be assumed that many young women enjoy flexible work styles while participating in e-commerce, which may lead to a positive predisposition to having children.

Conversely, studies also elaborate on three potential negative effects:

Substitution effect. As rural e-commerce provides more employment opportunities, including jobs with higher wages for women and young people, the opportunity cost of having children increases. Employment opportunities are limited to running e-shops, such as Taobao shops, Taobao rural service centers, and county service centers by JD.com and e-commerce-related industries such as web design and express delivery. The boom in Taobao-related businesses has created employment opportunities for women who would

[6] Case studies such as Shaji in Jiangsu and Caoxian in Shandong show that many young and talented people, including women, have returned to their hometowns in rural areas and are making an income equal to or more than what they earned as migrant workers in cities. Simultaneously, they are enjoying family life with their elders and children (Luo and Niu, 2019). Regarding the effect of income in the Becker model, in addition to the direct income effect, there is a "price of quality" effect for children that grows with income, which grows in proportion with the number of children. As a result, an increase in income is expected to have a positive effect on, for example, the fertility of the first child (with the income effect outweighing the price effect) but a negative effect on the third and younger children (with the price effect outweighing the income effect).

otherwise have stayed at home. According to the World Bank and Alibaba (2019), approximately one-third of e-shop owners and nearly half of e-shop workers in Taobao villages are female. Fan (2019) conducted interviews with Taobao shop owners and found that these women were often excluded from full-time employment because of pregnancy, childbirth, and breastfeeding. However, running a Taobao shop or working as a Taobao customer service representative allowed them to work wherever and whenever it was convenient for them, thereby increasing employment rates and income. Although rural e-commerce mitigates the trade-off between birth rate and employment, it also increases the opportunity costs of having children because these women have to spend more time working.

Changes in traditional values. Those who participate in e-commerce use the Internet for both work and leisure purposes. Rural e-commerce can instill modern childbearing values through the expansion of online interactions with urban customers. Information technology has deeply affected social structures and everyday lives in numerous villages worldwide (Kilpeläinen and Seppänen, 2014). Lin et al. (2016) found that China's Taobao villages were a prime example of this phenomenon. They suggested that the development of e-commerce and networks changed the common beliefs people held in rural life, the affection for villages, and the pace of life of the local people. Accordingly, traditional values of childbearing, such as raising children to take care of their parents when they are old, preferences for sons over daughters, and believing that more children will bring more happiness, are weakened to some extent. Moreover, according to the Ministry of Commerce, China (2018), 80% of Taobao shops are opened by people between 16 and 40 years of age. Furthermore, 76% of rural e-tailers were 20–29 years old, and 19% were aged 30–39 years. Therefore, most e-commerce users are relatively young and not bound by traditional values.

In summary, while rural e-commerce can increase birth rate by increasing income, providing childcare support to parents in the village, and allowing flexible working hours, it can also decrease birth rate through the substitution effect (opportunity costs of having a child) and the less traditional values of raising children. Butz and Ward (1979) found that while male (household) income has a positive effect on birth rate (income effect), female wages have a strong negative effect on birth rate (substitution effect). We assume that the negative effects arise mainly because the opportunity costs of having children outweigh the positive effects. This is because the World Bank and Alibaba (2019) show that the average annual household income per capita in Taobao villages (approximately 35,000 yuan in 2017) is nearly three times higher than the rural average in China (13,432 yuan in 2017) and close to the urban average (36,396 yuan in 2017). In the case of Jiangsu,

rural income in a county with Taobao villages is 1.1 to 1.3 times higher than in counties without Taobao villages based on data from 41 counties.

Moreover, we consider two potential heterogeneous effects. First, we assume that the negative effects of rural e-commerce development are smaller in counties with higher ratios of employment in the primary sectors because of the stronger traditional values of having children. Second, we assume that the negative effects of rural e-commerce development are larger in counties with higher rural income per capita because of the higher opportunity costs of having children.

2.3 Empirical studies on the determinants of birth rate from a macro-level perspective

Socioeconomic development is typically viewed as an influencing factor of the birth rate (Poston, 2000). This negative association between economic development and birth rate has been one of the most firmly established and accepted empirical relationships in the economic and social sciences (Doepke, 2004; Myrskylä, Kohler, and Billari, 2009).

Dyson and Murphy (1985) found that there was a growing awareness that birth rate may increase before a long-term decline and examined the relationship between economic development and birth rate. The study revealed an inverted U-shape in birth rate dynamics (birth rate increases at low-income levels but decreases at high-income levels). This can be interpreted as a demographic transition, which refers to the transition from a high birth rate and mortality regime, including child mortality, to a low birth rate and mortality regime, generating an inverted U-shape for net birth rate in the process (Dao, Dávila, and Greulich, 2021). Lehr (2009) examined the relationship between productivity measured by GDP per worker and birth rate and found an inverted U-shaped relationship[7]. Moreover, Myrskylä et al. (2009) and Luci-Greulich and Thévenon (2014) found that the relationship between socioeconomic development and birth rate reverses from negative to positive when a country attains an advanced economic position. Subsequently, birth rate and economic development increased simultaneously, opening a new debate on whether the former negative development of birth rate had taken the form of an inverted J-shaped

[7] During the process, there were important interactions between productivity and education. Increases in secondary education generated declines in birth rates regardless of the development stage (Lehr, 2009).

pattern[8] (Lacalle-Calderon et al., 2017).

Regarding other socioeconomic factors, existing studies outside China have revealed that population density is a key factor in declining birth rate (e.g., Kato, 2018; Lutz and Qiang, 2002; Lutz, Testa, and Penn, 2006). Lutz and Qiang (2002) interpreted population density as an indicator of urbanization. However, Kato (2018) treats population density as a proxy for the direct cost of raising children and the possibility of compatibility between childcare and married women's employment. Other than population density, higher educational standards and the incidence of nuclear families tended to result in higher birth rate. Conversely, higher ratios of aged persons in the total population and higher employment rates in primary industries tended to result in lower birth rate (Sasai, 2005).

Regarding the related literature for China (see **Appendix Table A1**), Chen et al. (2009) summarized the studies on China and found that they attributed birth-rate declines to the government's birth-control policy and accelerated economic development. Cai (2010) found that socioeconomic development contributed more to reducing birth rate than the one-child policy. Many studies have focused on the national level (Chen et al., 2009), while others have focused on the provincial level. However, few studies have focused on the county level. See Table A1 in the appendix for a comprehensive literature review. Several studies have demonstrated that variations in birth rate in China at the provincial level are closely related to variations in economic and social development. Specifically, they found that socioeconomic development negatively affects birth rate (e.g., Birdsall and Jamison, 1983; Chen et al., 2009; Poston, 2000; Poston and Gu, 1987). Some studies found that socioeconomic development, measured as GDP per capita, had positive effects on birth rate (e.g., Wang, Zhao, and Zhou, 2016; Yang, Chen, and Xu, 2013). However, most of these studies used province- and city-level data and could, thus, have different results.

Cai (2010) used county-level data to examine the factors affecting low birth rate in Jiangsu and Zhejiang provinces. The author found that socioeconomic indicators had a much stronger negative impact on birth rate than policies. Cai (2010) also showed that foreign direct investments (FDIs) have a statistically significant negative effect on birth rate, even after controlling for other socioeconomic development factors, suggesting an independent influence of global economic connections.

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[8] This debate is ongoing because studies such as those of Furuoka (2009, 2013) and Harttgen and Vollmer (2014) found no empirical evidence for the J-shaped pattern (Lacalle-Calderon et al., 2017).

Regarding other socioeconomic development factors, Yang et al. (2013) examined the relationship between fiscal expenditure on education and birth rate using provincial panel data. The results show that birth rate is negatively affected by educational expenditures. Li and Zhang (2008) examined the relationship between population composition and birth rate. They found that child-age dependency rates had a significant positive effect on birth rate, whereas older adults' dependency rates had a significant negative effect on birth rate.

In the Chinese context, population mobility and migration should be considered (e.g., Guo, 2008). Migration can affect birth rate directly and indirectly because it often interrupts or delays family formation and function. The current migration process in China is dominated by migration from rural to urban areas and from less-developed to more-developed areas (Cai, 2010), implying that migration has a negative effect on birth rate. Cai (2010) revealed that net migration has statistically significant negative effects on birth rate. Chen and Wu (2006) found that migrants in urban areas have a lower birth rate than those in both rural and urban populations.

Although these studies revealed birth-rate determinants using different levels of aggregate data, this study is the first to examine the impact of e-commerce on CBR. Additionally, this study contributes to the existing literature by addressing both heterogeneity and endogeneity problems using county-level panel data on Jiangsu and the IV method, which few studies have used.

3. Methodology

3.1 Model

To examine the impact of rural e-commerce development, measured as the establishment of Taobao villages, on CBR, we use a generalized difference-in-differences (GDD) estimation. This is because Taobao villages appear at different times in different counties. Therefore, it is necessary to adopt a GDD model[9]. Further, we used the fixed effects (FE) model to examine the impact of the existence of Taobao villages (breadth) and the number of Taobao villages (depth). This model addresses unobserved heterogeneity. Moreover,

[9] The two-group two-period simple DID design is nested in the GDD. The generalized design can be easily analyzed using a two-way fixed effects regression model (Wing, Simon, and Bello-Gomez, 2018).

we performed dynamic FE panel data estimations to consider that birth-rate decisions are made at least nine months prior to birth (Yurtseven, 2015). Studies using regional data outside China (e.g., Angeles, 2010; Iwasaki and Kumo, 2020; Yurtseven, 2015) have also performed dynamic panel data analyses.

The GDD model is constructed as follows:

$$CBR_{it} = \beta_0 + \beta_1 * Under\_treated_{it} + \beta_2 * X_{it} + \lambda_t + \mu_i + \varepsilon_{it} \quad (1)$$

where *i* represents county, *t* represents year, *CBR* represents the crude birth rate, and *Under_treated* represents the under-treatment period dummy (interaction term between the treatment and active dummy, which equals one after at least one Taobao village is established in a county), *X* represents a series of observable control variables, λ represents time fixed effects, μ represents county fixed effects, and ε is the error term. The FE model is constructed as follows:

$$CBR_{it} = \beta_0 + \beta_1 * EC_{it} + \beta_2 * X_{it} + \lambda_t + \mu_i + \varepsilon_{it}\,, \quad (2)$$

where *i* represents county, *t* represents year, *CBR* represents the crude birth rate, and *EC* represents rural e-commerce development measured by two indicators: the Taobao village dummy (one if a county has at least one Taobao village) and the logarithm of the number of Taobao villages. Furthermore, *X* represents a series of observable control variables, λ represents time fixed effects, μ represents county fixed effects, and ε is the error term.

The dynamic fixed effects model is constructed as follows:

$$CBR_{it} = \gamma * CBR_{i,t-1} + \beta_1 * EC_{it} + \beta' * X_{it} + \lambda_t + \mu_i + \varepsilon_{it}, \quad (3)$$

where *i* represents the county, *t* represents the recent year, *t-1* represents the prior year (*t-1* time point), and *CBR* represents the crude birth rate. In this setting, we take the one-year lagged value of the dependent variable. *X* represents the independent variables; λ and μ are the (unobserved) time-specific and individual effects, respectively; and ε is the error term.

We also consider the potential endogeneity of Taobao village variables. Taobao villages may have systematically different characteristics from non-Taobao villages; there may be self-selection. If these differences are unobserved but correlated with the outcome variable of CBR, then the Taobao village dummy is endogenous. Some previous studies (e.g., Chang and Just, 2009; Hübler and Hartje, 2016) have found that the Internet-use

variable is potentially endogenous because households choose whether to use broadband Internet services. Moreover, Luo and Niu (2019) found that e-commerce participation was not random in Taobao villages. Thus, we conducted IV estimations as a robustness check. The IV method is as follows:

$$EC_{it} = a + \beta_z Z_{it} + \gamma X_{it} + \mu_{it}, \quad (4)$$

$$CBR_{it} = a + \beta_{EC} \widehat{EC}_{it} + \gamma X_{it} + \varepsilon_{it,} \quad (5)$$

$$corr(Z, \varepsilon) = 0, \text{ and } corr(Z, EC) \neq 0, \quad (6)$$

where EC is the probability of being a Taobao village and the number of Taobao villages and Z represents the IVs. We attempted to use the post and telecommunications business volumes from ten years ago, the number of households with broadband Internet access, and annual rainfall in cities for Taobao village variables as the IVs and performed a set of tests. IVs need to fit a set of conditions, such as the relevance and exclusion restriction conditions. Based on the results of the weak identification and endogenous tests[10], we found that the number of mobile phone subscribers before ten years in cities was an appropriate IV. We used this as an IV in this study. We report and discuss the test results of IV in Section 4.2.

We also used a combination of the fixed effect and instrumental variable methods (FE-IV) to address the endogeneity issue.

We also used the Arellano–Bover/Blundell–Bond linear dynamic panel data model to address endogeneity. We adopted a consistent generalized method of moments (GMM) estimator derived by Arellano and Bond (1991)[11].

3.2 Original data conductions

To examine the impact of rural e-commerce on CBR, a county-level dataset was

[10] We used command "xtivreg2" in Stata. Xtivreg2 reports the critical values according to Stock and Yogo (2005) for IV estimation in the main regression output. The reported test statistic is the Cragg-Donald statistic.

[11] It should be noted that this estimator is designed for datasets with many panels and few periods. However, GMM is used in several existing studies in the Chinese context (e.g., Fang, Chen, Yuan, and Gao, 2021; Li, 2019; Yang et al., 2013).

constructed based on the statistical yearbooks of Jiangsu from 2011 to 2019. Forty-one county-level administrative divisions (of the 96 in Jiangsu) were used due to the unavailability of data on urban districts. The Taobao village list, published by Alibaba each year since 2013, was used to determine the number of Taobao villages.

While e-commerce growth has mostly expanded in urban areas, the Chinese government has recently announced the expansion of e-commerce to rural areas as a priority national policy. Their objective is to foster rural economic development and reduce the urban-rural economic divide. The policy agenda of "Alleviating Poverty through E-Commerce" has been featured in the government's No. 1 Central Document each year since 2014 (Couture et al., 2018). In the non-governmental sector, the Alibaba Group,[12] China's largest e-commerce company, launched its Rural Taobao Program in 2014. Taobao is an online trading platform that was founded by Alibaba. Their main objectives are to enable rural residents to have greater access to a larger variety of goods and services and to help farmers earn more by selling agricultural products directly to urban consumers using online platforms. One prominent example of the development of rural e-commerce in China is Taobao villages. Ali Research—Alibaba Group's research unit—identifies a Taobao village as follows: (1) trading place: an operation located in rural areas with an administrative unit; (2) trading volume: the annual trading volume of e-commerce exceeds RMB 10 million; and (3) scale of online merchants: active online stores exceed 100 or account for over 10% of local households. According to the World Bank and Alibaba (2019), the income levels of households in Taobao villages are similar to those of urban households and much higher than those of households in rural areas (non-Taobao villages).

In accordance with Zheng et al. (2009), we chose Jiangsu for its economic and demographic characteristics such as its extremely low birth rate and unique birth-rate policies. Jiangsu is one of the most developed provinces, and its birth rate is one of the lowest in China, with a TFR of 0.967 in 2000 and 1.054 in 2010 based on China's 2000 and 2010 censuses. Since 2000, the CBR has been lower than ten per thousand. Moreover, its natural rate of increase has been lower than three per thousand since 2000. The trajectory of the birth rate change in Jiangsu was considerably similar to that in China

[12] China has two large e-commerce platform companies—Alibaba and JD—and many smaller ones. Alibaba Group has the largest share of the e-commerce market. According to eMarketer.com, in 2018, Alibaba accounted for 58% of the total retail e-commerce sales, followed by JD.com (16%), while the market shares of the smaller companies, despite the rapid growth witnessed by some in recent years, remain less than 5% each (World Bank and Alibaba, 2019).

from 1975 to 2000 but at a lower level (Zheng et al., 2009).

Unlike most other provinces in China that allow rural couples to have a second child if their first child is a girl (Gu et al., 2007), Jiangsu is one of the only two provinces, along with Sichuan, that has implemented a province-wide one-child policy for the past two and a half decades, restricting both urban and rural couples to one child. However, Jiangsu's strict policy is benign. In the case of couples with agricultural household registration (hukou) status, the current policy allows couples to have two children if either of them is the only child. In the case of couples with non-agricultural registration status, the policy allows married couples, in which both partners have no siblings, to have two children (Zheng et al., 2009).

3.3 Variables

The dependent variable in this study was CBR because of the unavailability of TFR data for each year. The use of TFR instead of CBR is preferable. As CBR is affected by age composition, provinces with larger proportions of women of childbearing age have higher CBRs, even for the same average number of children per woman. However, CBR is highly correlated with TFR across countries (e.g., Mauldin, Berelson, and Sykes, 1978; Poston, 2000). In accordance with Birdsall and Jamison (1983), we would expect differences in age composition across a single country's regions to be smaller than the differences across several countries because there would have been larger variations in birth and mortality rates in the latter case. As we analyzed a single province, Jiangsu, we assumed that differences in age composition across regions were insignificant.

The CBR is the ratio between the number of live births in a population during a given year and the total mid-year population for the same year, usually multiplied by 1000. Several studies in China have used CBR instead of TFR (e.g., Wang et al., 2016; Yang et al., 2013).

Table 1 shows the number of counties with at least one Taobao village and the number of Taobao villages in the 41 counties used in this study.

-----Table 1---

The following variables were included as controls: First, we controlled for population

density as an indicator of the direct cost of raising children and the possibility of compatibility between childcare and the employment of married women. The influence of other relevant socioeconomic variables on birth rate has been studied extensively. These include infant mortality, GDP per capita, women's labor force participation, women's literacy, and the proportion of the population living in urban areas (Lutz et al., 2006). Considering existing studies in China and data limitations, we used indicators of economic development, globalization, demography, education, health, employment structure, and living conditions. In addition to the above-mentioned control variables, we introduced time (year) fixed effects as control variables to capture the common shocks to birth rate that occur every year.

Population density: This should be controlled for based on findings outside China (e.g., Lutz et al., 2006). Although a few studies have addressed the relationship between population density and reproduction in humans, they have generally found a significantly negative relationship (Easterlin, 1976; Firebaugh, 1982; Lutz and Qiang, 2002). Indeed, this negative relationship between population density and growth rate is at the heart of population biology (Sibly and Hone, 2003). Areas with higher population densities have lower agricultural incomes, and marriage and children are delayed (Malthus, 1807). Preferences for having children are expected to decline with the increased costs of rearing children, such as childcare, housing, education, and trade-offs with economically productive work (Becker, 1991). These factors can increase with the population density (Lutz et al., 2006). Kato (2018) treats population density as a proxy for the direct cost of raising children and the possibility of compatibility between childcare and the employment of married women, revealing that municipalities with higher population densities have lower TFRs. Based on this, we expected the coefficient to be negative.

Real rural income and real GDP per capita: Real rural income measures the effects of rural economic development. The latter measures the effects of overall economic development. It is commonly accepted in empirical studies that there is a negative association between economic development and birth rate (Lacalle-Calderon et al., 2017). Many studies have attempted to explain this negative association, known as demographic transition, from various theoretical, ideological, and disciplinary perspectives, including biology, sociology, and economics (Anderson and Kohler, 2015; Lesthaeghe, 1995). Although empirical evidence shows the negative effects of socioeconomic development on birth rate (see Section 2.3), some studies in China reveal the positive effects of GDP per capita on CBR (e.g., Wang et al., 2016; Yang et al., 2013). We also consider the potential nonlinear relationship between GDP per capita and CBR. This is because the long-term world historical data used in studies by Dyson and Murphy (1985) and Kremer

(1993) suggested that birth rate increased at low-income levels but decreased at high-income levels (Tabata, 2003). Moreover, Myrskylä et al. (2009), Luci-Greulich and Thévennon (2014), and Lacalle-Calderon et al. (2017) found an inverted J-shaped pattern between economic development and birth rate. Therefore, we expect economic development to have a negative impact on birth rates. However, economic development can also have positive or nonlinear impacts on birth rate according to Chinese and recent empirical studies.

Foreign capital actually used per capita: This is used as a proxy for FDI per capita and to measure the effects of globalization. The amount of foreign capital used comprises foreign loans and direct and foreign investment. Foreign capital is unevenly distributed across regions. FDI is more concentrated in large urban centers than in remote rural areas. Cai (2010) revealed the negative effects of FDI per capita on TFR, even after controlling for other socioeconomic development factors. This suggests that global economic connections independently influence TFR. Therefore, we expected the coefficient to be negative.

The ratio of fiscal expenditure to GDP: This is used to measure the effects of government intervention. Some studies (e.g., Wang et al., 2016; Yang et al., 2013) consider the effects of government intervention based on the structure of fiscal expenditure. Wang et al. (2016) used the ratio of fiscal expenditure on social security to the total fiscal expenditure and revealed that it had a significant negative impact on birth rates. Yang et al. (2013) found that government spending on education restrains birth rates under certain conditions. Further, theoretical analyses revealed that the impact of fiscal expenditure on birth rates depends on the comparison between income and substitution effects. If the income effect exceeds the substitution effect, an increase in government spending on education can lead to a lower birth rate (Yang et al., 2013). However, due to data limitations, we cannot reveal the constitutions of fiscal expenditure. Instead, we use the ratio of fiscal expenditures to GDP.

Female population rate: This indicator is used as a proxy for the population structure. It has two effects on the CBR. First, an increase in the ratio may reduce the hurdle to marriage for males and increase the number of births through higher marriage rates (positive effect). On the contrary, as life expectancy is longer for females, it is assumed that the female population ratio would include many elderly women. It can also be expected to include many women who are already married and have children and the ones have no desire to have children. Therefore, a mere increase in the female population ratio may decrease CBR (negative effect). Thus, the result of the indicator indicates the total

effect (or net effect), including the positive and negative effects.

Migration ratio: First, the number of immigrants is determined by deducting people in agricultural household registers from the resident population. Second, the number of immigrants is divided by the resident population. The result gives the migration ratio, which is used to measure the effect of migration. Migrant workers are attracted to urbanized counties that have many employment opportunities. Based on existing studies, mostly from developing countries, Koike (2006) found that the birth rate has decreased because of migration to urban areas. In other words, when people migrate to urban areas, their birth rate is lower than those of people who remain in rural areas. Therefore, we expected the coefficient to be negative.

Number of enrolled students in regular secondary school per 100,000 people: This indicator is used as a proxy for levels of education and human capital because of the unavailability of data on average years of education. The availability of educational opportunities is expressed as the number of graduates from higher education per 10,000 residents (Iwasaki and Kumo, 2020). Similarly, Li and Zhang (2008) used the ratio of the number of people who graduated from colleges or universities to the total population as an indicator of higher education level. Improvements in education, especially for women, have been shown to have an important depressing effect on birth rate (Axinn and Barber, 2001; Bongaarts, 2003). Lutz et al. (2006) found a significant negative relationship between women's literacy and TFR. However, Cai (2010) used the percentage of women aged 20–29 years with a middle school education as a proxy for female educational standards and revealed that this variable had virtually no effect on birth rate. Based on this, we expected the coefficient to be negative.

Number of health institutions: This number is used to measure the effects of health and human capital. This indicator was used as a proxy for health care standards. Wang et al. (2016) used the number of health institutions per 1,000 people to reflect the standards of social health development; however, they did not have a significant positive effect on CBR. Iwasaki and Kumo (2020) measured the quality of social infrastructure using the number of hospital beds per 10,000 residents and found that it had a significant positive impact on birth rate. Thus, we expected the coefficient to be positive.

Ratio of employment in the primary industry: This is used to measure the effects of employment structure. It is assumed that the primary sector offers more employment opportunities and those who work in agriculture tend to have more traditional values surrounding having children. Therefore, this ratio should have a positive effect on the CBR. Yang et al. (2013) used the ratio of non-agricultural employment to total

employment to assess changes in parental employment. Fei (1983) found that increases in rural populations could mainly be attributed to people's concerns about their old age because of the absence of rural social security systems, which increased the number of babies. Considering the experiences of developed Western countries in the process of industrialization, a demographic transition occurs. As the non-agricultural sector develops, birth rate gradually decreases and the average level of education increases (Yang et al., 2013).

Ratio of rural employment in tertiary industry: This indicator measures the effects of rural employment structures. The assumption is that rural e-commerce development promotes non-agricultural employment and increases demand for the service sector. The higher the ratio of rural employment in tertiary industries, the more residents work in rural areas and earn nonagricultural income. This decreases the demand for migration. People have more time to spend raising children, thus increasing their birth rate. Conversely, non-agricultural income can increase opportunity costs. Therefore, this aspect must be empirically examined and controlled for to measure the net impact of rural e-commerce development on birth rate.

Average living space of rural residents: This was used to measure the effects of living conditions. The average living space of rural residents determines their number of children because it reflects the cost of housing and whether there is additional room for children. Therefore, the average living space of rural residents is expected to have a positive effect on the CBR. Although this aspect has not been considered in studies on China thus far, Iwasaki and Kumo (2020) used floor space per capita as a proxy for the intensity of the housing supply in Russia and found that it had a significant positive impact on birth rate.

We calculated the Variance inflation factor (VIF) values of the independent variables (see **Appendix Table A2**). As the values were lower than 10, it can be considered that there was no multicollinearity issue among the variables. The summary statistics of the variables included in the analyses are presented in **Appendix Table A3**. The mean CBR was approximately 0.011, which indicates 11 live births per 1000 population. The mean of the Taobao village dummy variable is approximately 0.339. Additionally, the mean number of Taobao villages in a county is approximately 3.317, with a minimum of zero and a maximum of 112.

4. Empirical Results

4.1 Estimation results of the GDD model

Table 2 presents the estimation results of the GDD model, which considers CBR as the dependent variable. The coefficient of *Under_treated* is the difference-in-differences estimator of treatment effect. As shown in this table, the regression coefficient of *Under_treated* is negative and statistically significant at the 10% and 5% levels in Columns 1 and 2, respectively. The regression coefficient of real rural income per capita is negative and that of its squared term is positive at the 1% significance level. Thus, we find a U-shaped impact of real rural income per capita on the CBR. The regression coefficient of the ratio of employment in the primary sector was positive at the 5% significance level. Furthermore, the regression coefficient of the average living space of rural residents was negative at the 10% significance level. Moreover, the regression coefficient of the number of enrolled students in regular secondary schools to the total population was negative at the 5% significance level.

---Table 2---

Both simple DID and GDD designs rely on the assumption that the important unmeasured variables are either time-invariant group attributes or group-invariant time-varying factors. These restrictions imply that the time series of outcomes for each group should differ by a fixed amount in each period and should exhibit a common set of period-specific changes. The time series resembles a set of parallel lines (Wing et al., 2018). However, this study adopts a setup with variations in the treatment timing of the Taobao village appearance. Thus, although it is not possible to create a graph of the common (parallel) trends of the simple DID, we create the graph by considering 2013, when Taobao villages first appeared, and 2015, when the number of Taobao villages surged, as the treatment period. Figures 1 and 2 show the quasi-parallel trend assumption with the treatment timing in 2013 and 2015, respectively. The parallel trend assumption seems to be satisfied. Thus, we ensured the internal validity of the GDD models.

---Figure1---

---Figure2---

4.2 Estimation results of the FE model

Table 3 presents the estimation results of the FE model using the CBR as the dependent variable. The coefficients of the Taobao village dummy and number of Taobao villages are estimators of the effects of rural e-commerce development. Depending on the variables used, the estimation models can be divided into various types. Each model used the previous model as a base and added additional variables. Model 1 uses the rural e-commerce factor and year fixed effects as the independent variables. Model 2 adds population density and educational factors, and Model 3 adds industry and migration factors. Furthermore, Model 4 adds GDP per capita and fiscal expenditure factors, and Model 5 adds all control variables.

As Table 3 shows, the regression coefficient of the Taobao village dummy is negative at the 10% significance level in Model 5. Moreover, the regression coefficients of the number of Taobao villages were negative at the 1% significance level in Models 4 and 5. Thus, we find that rural e-commerce development has a significantly negative impact on CBR. All the results are generally consistent with those reported in Table 2.

---Table3---

Table 4 presents the estimation results of the FE, FE-IV, dynamic FE, dynamic FE-IV, and dynamic panel data model models (GMM) that take CBR as the dependent variable. The coefficients of the Taobao village dummy and number of Taobao villages are estimators of the effects of rural e-commerce. The FE model results are presented in Columns 1 and 2. The regression coefficients of the Taobao village dummy and number of Taobao villages are negative and statistically significant at the 10% and 1% levels, respectively. The results of the FE-IV model were generally consistent with those of the FE model. As shown in columns 3 and 4, the regression coefficients of the Taobao village dummy and number of Taobao villages are negative and statistically significant at the 10% and 5% levels, respectively.

---Table4---

The IV used in Table 4 is the logarithm of the number of mobile phone subscribers

in cities ten years ago[13]. This IV has passed a weak identification test; thus, it meets the criterion of the instrumental variable—"relevance." Therefore, we assume that there are no serious issues on "relevance." Regarding another criterion of IV—"exclusion restriction" —, the number of mobile phone subscribers in a province ten years ago is a historical variable; it can be predicted that it does not directly affect the current CBR in counties, except through the development of rural e-commerce—Taobao village[14]. Based on Alibaba's criteria for a Taobao village, as defined in Section 3.1, we find that rural e-commerce development has a significant negative impact on CBR.

The estimation results of the dynamic FE model were generally consistent with those of the FE model. As shown in columns 5 and 6, the regression coefficients of the Taobao village dummy and the number of Taobao villages are negative and statistically significant at the 5% and 1% levels, respectively.

The results of the dynamic FE-IV are generally consistent with those of the FE model. As shown in columns 7 and 8, the coefficient of the Taobao village dummy and the number of Taobao villages are negative and statistically significant at the 5% and 10% levels, respectively.

Columns 9 and 10 show the results of the dynamic panel data model using the GMM estimator. The coefficient of Taobao villages is negative but statistically insignificant, whereas that of the number of Taobao villages is negative and statistically significant at the 10% level.

Regarding other relevant socioeconomic variables, the FE estimation results showed that the regression coefficient of population density was negative at the 5% significance level. This result is consistent with existing studies from both developed and developing countries (e.g., Kato, 2018; Lutz and Qiang, 2002; Lutz et al., 2006). The regression coefficient of real rural income per capita is negative and that of its squared term is positive at the 1% significance level in both the FE and dynamic FE models. Thus, we find a U-shaped impact of real rural income per capita on the CBR. The regression coefficient of the ratio of employment in the primary sector was positive at the 5%

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[13] Annual rainfall in cities did not pass the weak identification test. It also failed to meet the general criteria for t-values that should be larger than $\sqrt{10} \approx 3.2$ or the corresponding p-value that should be less than 0.0016. Morita (2014) and Kurt Schmidheiny's (2020) educational materials provide a guide for the relevance of instruments.

[14] We adopt the approach of Conley et al. (2012) for further robustness checks. Even under the condition that our IVs violate the exclusion restriction, our results remain the robustness. The estimated bounds for 95% confidence intervals are available upon request.

significance level in the FE models. The regression coefficient of the average living space of rural residents was negative at the 5% significance level in both FE and dynamic FE-IV models. Furthermore, the regression coefficient of the number of enrolled students in regular secondary schools to the total population is negative at the 5% significance level in both the FE and dynamic FE-IV models.

Next, we evaluate the magnitude of the results based on the fact that if the parameter is statistically significant and its absolute value is large enough, it becomes meaningful for us to interpret it (e.g., Morita, 2014). Given that the average CBR was 11‰, the magnitude was not small. For example, taking Liyang as a county without a Taobao village in 2019, the CBR in 2019 was 7‰. The estimate of the Taobao village dummy variable is about -0.001, and with the emergence of Taobao village, the CBR falls by 1 to 6‰. In other words, CBR was reduced by approximately 14.3%. In addition, the CBR for Siyang, which had 10 Taobao villages in 2019, was 10‰. The estimated Taobao village quantity is approximately -0.001, suggesting that if the number of Taobao villages increases by 10% to 11 villages, the CBR will decrease by 0.01 (0.001*10) to 9‰. In other words, the CBR decreased by 10%. This implies that e-commerce has a significant effect on the CER.

4.3 Robustness checks

As mentioned in the Introduction, in October 2015, China announced that the one-child policy had been replaced by a universal two-child policy. Since January 1, 2016, all Chinese couples have been allowed to have two children. To consider the potential effects of this policy change on CBR, the analysis period was divided into periods before the change (2011–2015) and those after the change (2016–2019). The coefficient of the number of Taobao villages is negative at the 10% significance level for the period 2011–2015. The results are presented in **Table A4 in the Appendix**.

To further test the robustness of our results, we employ interaction terms between the policy change and Taobao village variables to determine whether there are any potential heterogeneous effects of the policy change on rural e-commerce. The results are presented in **Table A5 of the Appendix**. The coefficients of the policy change are negative and not statistically significant. Moreover, neither interaction term was statistically significant. Thus, it is implied that the effects of policy changes on CBR are limited. The coefficient of the number of Taobao villages was negative at the 1% significance level.

4.4 Estimation results by group

Although Jiangsu is one of the most developed provinces in China, large regional disparities exist, especially between poorer northern Jiangsu (Subei) and richer southern Jiangsu (Sunan) (Wei and Fan, 2000). These disparities have always existed, and local governments are concerned with them. In fact, Jiangsu is often viewed as "two provinces in one" (Su and Veeck, 1995). Another popular notion is that the province is divided into three areas: south (Sunan), central (Suzhong), and northern (Subei). Suzhong is considered to be in a transitional stage between Sunan and Subei. Regardless of how the province is divided, spatial disparities within provinces are substantial (Wei and Fan, 2000). To control for the heterogeneities among these three regions, we employ FE estimations using the three regions as subsamples (Subei, Suzhong, and Sunan).

Table 5 presents the results for the sub-samples. In Subei, the regression coefficients of the number of Taobao villages were negative and statistically significant at the 1% level. In Suzhong, the coefficient of the number of Taobao villages is negative and statistically significant at the 1% level, whereas it is not statistically significant in Sunan. Thus, the effects of rural e-commerce on CBR are heterogeneous and more prominent in less-developed areas such as Subei. However, the sample sizes of Suzhong and Sunan were relatively small.

---Table5---

4.5 Heterogeneous effects

We examined the heterogeneous effects of rural e-commerce development on CBR, as measured by the establishment of Taobao villages. The model results, which include the interaction terms between the Taobao village variables and the corresponding variables, are reported in **Table 6**. In particular, we focus on two socioeconomic conditions: employment structure and economic development. We measure employment structure as the ratio of employment in the primary sector because employment in this sector can strengthen the traditional values of having children, such as raising children to take care of one during old age and more children equaling more happiness. Thus, the effect of modern values on having children caused by rural e-commerce development is assumed to be weaker. Regarding economic development, we find U-shaped impacts of rural

income and GDP per capita on the CBR. We assume that the opportunity cost of having children increases as the economy develops. However, we also assume that opportunity costs increase less in counties with more online shop owners, because of flexible working styles. Thus, the negative impact of economic development is mitigated by the positive effects of Taobao villages.

---Table6---

Table 6 further shows that the regression coefficients of the Taobao village dummy are negative at the 10% and 1% significance levels in columns 3 and 5, respectively. The regression coefficients of the number of Taobao villages are negative at the 1% significance level in both Columns 4 and 6. Therefore, the estimation results are consistent with those of the FE models.

Regarding the heterogeneous effects of rural e-commerce, as Columns 1 and 2 show, the regression coefficient of the interaction terms of the Taobao village variables and the ratio of employment in the primary sector are negative, contrary to expectations. Although the regression coefficients of the Taobao village variables are positive in Columns 1 and 2, given the average ratio of employment in the primary industry (0.252), dCBR/dTaobao = 0.003-0.013*(0.252) = -0.0003, Taobao's impact on CBR is negative. A possible interpretation of the unexpected results is that those who engage in rural e-commerce, such as running Taobao online shops, work extremely hard to still have time to raise children. Conversely, as shown in Columns 3 and 4, the regression coefficient of the interaction term of the Taobao village variable and rural income per capita was positive, as expected. Although we find U-shaped impacts of rural income per capita on CBR, the results of the heterogeneous effects are in line with the latter half. This implies that in high-income countries, when income levels exceed a certain threshold, CBR tends to increase.

Using GDP per capita instead of rural income per capita, the interaction term is also positive at the 1% significance level, as shown in Columns 5 and 6. Thus, the negative effects of rural e-commerce can be mitigated through economic development. One interpretation is that although the opportunity cost of having a child increases and enhancing a child's quality is regarded as more important than the number of children, the income effect strengthens along with increases in income. This is partly in line with Luci-Greulich and Thévenon (2014), who revealed that a strong negative correlation between GDP per capita and TFR does not hold for high levels of per capita economic output. Specifically, the relationship weakens and appears to reverse at high levels of GDP

per capita into an inverted J-shaped birth rate pattern, coinciding with economic development.

Based on the findings in Table 5, the effects of rural e-commerce on CBR are heterogeneous and more prominent in less-developed areas, such as Subei. The CBR was also the highest in Subei, with a mean CBR of 13.90 ‰ during the analysis period. Therefore, as another final heterogeneous effect of rural e-commerce development on CBR, we examine whether the effects of Taobao villages on CBR are heterogeneous between high and low CBR counties. When the negative impact of e-commerce on CBR is larger in counties with high historical CBR, the price effect is larger than the income effect. The results of empirical studies using survey data, which show that as the number of children increases, the price effect is larger than the income effect from increased income, can also be verified at the regional level, albeit in a simplified manner. The results from the model including the interaction terms between Taobao village variables and CBR three years ago are reported in **Table 7**. Although the regression coefficients of the Taobao village variables are positive in column 1, given the average ratio of CBR three years ago (0.011), we calculated dCBR/dTaobao = 0.003-0.287*(0.011) = -0.0002; the Taobao village's impact on the CBR is negative, indicating that the negative effects of Taobao village in the recent period are greater in the counties with a higher CBR before three years ago. The results suggest that the higher the CBR, the stronger the price effect compared to the income effect of e-commerce development.

---Table7---

5. Conclusion

We analyzed the impact of rural e-commerce on birth rate, specifically the CBR in Jiangsu. Considering that Taobao villages, as defined by Ali Research, are prominent examples of the development of rural e-commerce in China, we measure rural e-commerce development using two indicators: whether there is at least one Taobao village and the number of Taobao villages in a county. Utilizing county-level panel data on Jiangsu based on GDD, FE, FE-IV, dynamic FE, dynamic FE-IV, and dynamic panel (GMM) models, we find that rural e-commerce reduces CBR when all other independent variables are constant. Furthermore, we find that economic development, measured by both rural income and GDP per capita, has a U-shaped impact on CBR. In other words, economic development first decreases CBR until a threshold is reached and then increases it. Regarding other socioeconomic factors, counties with higher population densities had lower CBRs. Counties with higher ratios of primary-sector employment showed higher

CBRs. Moreover, analyses of the heterogeneous effects reveal that the negative impact of rural e-commerce on CBR decreases with economic development.

To the best of our knowledge, the impact of rural e-commerce on CBR has not been studied. However, if we interpret e-commerce in a broad sense, there are relevant studies on the impact of the Internet on birth rate. Using German panel data at the county level, Billari et al. (2019) find positive effects of broadband Internet on fertility. Although our findings do not support these results, they are informative and meaningful in the Chinese context.

Regarding policy implications, as rural e-commerce has a negative impact on CBR, the Jiangsu government should consider policies to reduce the opportunity cost of childbirth through rural e-commerce to address the declining birthrate. In addition, the Jiangsu government should emphasize flexibility and discretion in e-commerce related jobs so that more people recognize the advantages of free time for raising children. Additionally, rural e-commerce poverty alleviation has attracted attention (Li, Wang, and Zhao, 2021), and numerous cases show the prosperity of Taobao villages and that people gain wealth and have better lives by participating in e-commerce (Luo and Niu, 2019). Therefore, rural e-commerce should be further developed in accordance with the Chinese government's expansion of e-commerce to rural areas as a priority national policy. However, to prevent a decline in birth rate, the positive impacts of rural e-commerce on birth rate, such as flexibility and discretion in e-commerce related jobs, should be emphasized. Finally, based on the results of the heterogeneous effects, local governments can mitigate the negative effects of rural e-commerce on CBRs by prioritizing the promotion of rural e-commerce in economically developed areas that have lower ratios of employment in the primary industry.

A limitation of this study is that we examined only a single province. Future studies could examine the impact of rural or general e-commerce on birth rate in other provinces, in both urban and rural areas. Another limitation of this study is that population structure indicators were not controlled for due to data unavailability. For example, although this study controls for the female population and migration ratios, other factors such as women's education level and age structure (e.g., the ratio of women in reproductive age [15–49 years]) were not controlled in the analyses. Detailed research that includes rich population information will become a new challenge in the future. As e-commerce is a new topic in the literature (Luo and Niu, 2019), the influence of e-commerce on birth rate should be studied further using both micro- and macro-level data in China.

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Table 1 Taobao villages in Jiangsu

Year	2013	2014	2015	2016	2017	2018	2019
Number of counties with at least one Taobao village	2	8	21	23	24	25	25
Total number of Taobao villages in Jiangsu	3	25	127	201	262	452	615
Number of Taobao villages in the 41 sample counties	2	15	104	151	195	303	454

Table 2 Estimation results of the generalized difference-in-differences model

VARIABLES	(1) GDD	(2) GDD
Under_treated	-0.001*	-0.001**
	(0.001)	(0.001)
ln(population density)	-0.004*	-0.005**
	(0.002)	(0.002)
ln(the number of enrolled students in regular secondary school per 100000 persons)	-0.004*	-0.005**
	(0.002)	(0.002)
ln(the number of health institutions)	0.000	0.000
	(0.000)	(0.000)
the ratio of employment of primary sector	0.015*	0.017**
	(0.008)	(0.008)
female ratio	-0.108***	-0.113***
	(0.039)	(0.038)
the ratio of migration to the total residential population	-0.004	-0.007
	(0.015)	(0.015)
ln(real rural income per capita)	-0.270***	-0.265***
	(0.057)	(0.058)
ln(squared of real rural income per capita)	0.014***	0.013***
	(0.003)	(0.003)
the ratio of government expenditure to GDP	0.005	0.000
	(0.016)	(0.015)
ln(amount of foreign capital actually used)		0.000
		(0.000)
the ratio of rural employment of tertiary sector		0.017
		(0.013)
ln(average living space of rural residents)		-0.003*
		(0.002)
year fixed effects	Yes	Yes
Constant	1.458***	1.457***
	(0.286)	(0.287)
Observations	369	369
Number of county_id	41	41
Within R-squared	0.477	0.488
Between R-squared	0.403	0.310
Overall R-squared	0.357	0.275

Notes: Robust standard errors in parentheses; *** $p<0.01$, ** $p<0.05$, * $p<0.1$

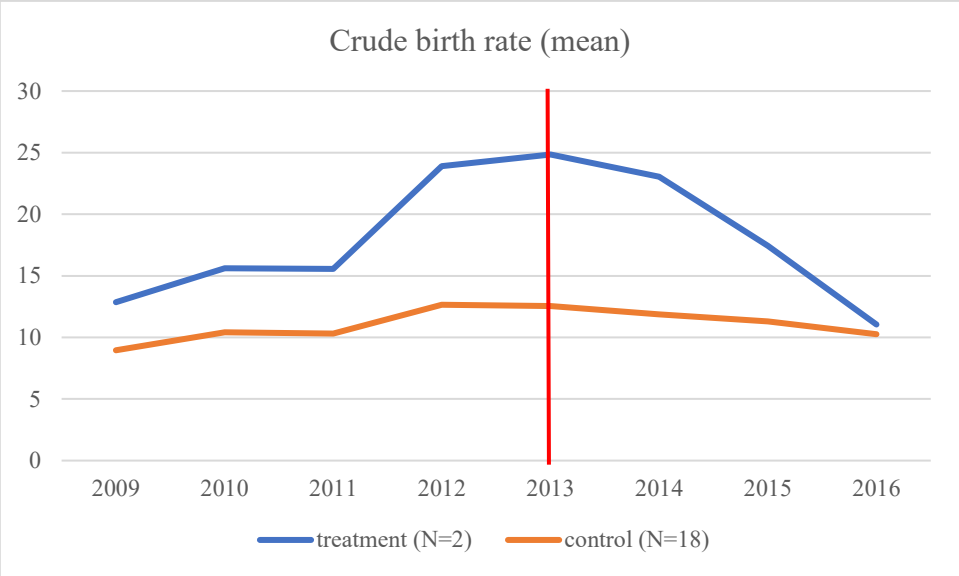

Figure 1 Parallel trend assumption (treatment timing in 2013)

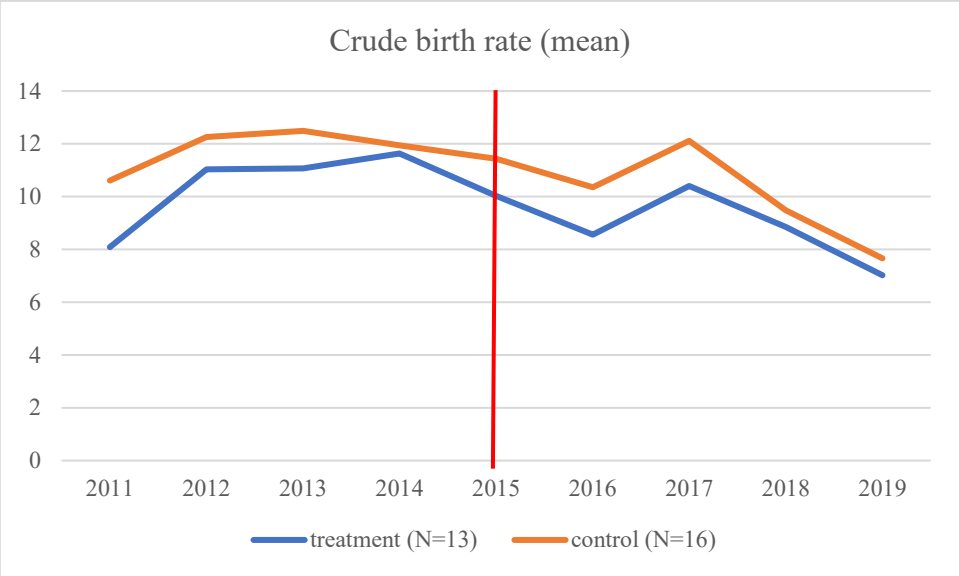

Figure 2 Parallel trend assumption (treatment timing in 2015)

Table 3 Estimation results of the fixed effects model

VARIABLES	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
	FE									
	Model 1		Model 2		Model 3		Model 4		Model 5	
Taobao village	-0.000		-0.000		0.000		-0.001		-0.001*	
	(0.001)		(0.001)		(0.001)		(0.001)		(0.001)	
ln(the number of Taobao villages)		-0.000		-0.000		-0.000		-0.001***		-0.001***
		(0.000)		(0.000)		(0.000)		(0.000)		(0.000)
ln(population density)			0.000	0.001	-0.001	-0.000	-0.004*	-0.003*	-0.005**	-0.004**
			(0.002)	(0.001)	(0.002)	(0.001)	(0.002)	(0.002)	(0.002)	(0.002)
ln(the number of enrolled students in regular secondary school per 100000 persons)			-0.003	-0.003	-0.001	-0.001	-0.004	-0.004*	-0.004**	-0.005**
			(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)
ln(the number of health institutions)					0.002*	0.002**	0.000	0.000	0.000	0.000
					(0.001)	(0.001)	(0.000)	(0.000)	(0.000)	(0.000)
female population ratio					-0.041	-0.038	-0.109***	-0.112**	-0.113***	-0.119**
					(0.052)	(0.051)	(0.039)	(0.049)	(0.039)	(0.051)
the ratio of migration to the total residential population					0.012	0.008	-0.003	-0.011	-0.006	-0.016
					(0.014)	(0.013)	(0.015)	(0.016)	(0.015)	(0.015)
the ratio of employment of primary sector					0.024***	0.024***	0.015*	0.016**	0.017**	0.018**
					(0.008)	(0.008)	(0.008)	(0.008)	(0.008)	(0.008)
the ratio of government expenditure to GDP							0.005	0.004	0.000	0.001
							(0.016)	(0.016)	(0.015)	(0.014)
ln(real rural income per capita)							-0.264***	-0.289***	-0.258***	-0.278***
							(0.057)	(0.056)	(0.058)	(0.055)
ln(squared of real rural income per capita)							0.013***	0.015***	0.013***	0.014***

							(0.003)	(0.003)	(0.003)	(0.003)
ln(amount of foreign capital actually used)									0.000	0.000
									(0.000)	(0.000)
the ratio of rural employment of tertiary sector									0.017	0.012
									(0.013)	(0.013)
ln(average living space of rural residents)									-0.003*	-0.004**
									(0.002)	(0.002)
year fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Constant	0.010***	0.010***	0.037**	0.034**	0.027	0.022	1.427***	1.539***	1.427***	1.514***
	(0.000)	(0.000)	(0.017)	(0.016)	(0.030)	(0.030)	(0.285)	(0.280)	(0.285)	(0.275)
Observations	369	369	369	369	369	369	369	369	369	369
Number of county_id	41	41	41	41	41	41	41	41	41	41
Within R-squared	0.302	0.308	0.313	0.317	0.378	0.384	0.474	0.494	0.484	0.508
Between R-squared	0.018	0.045	0.586	0.620	0.452	0.466	0.412	0.376	0.318	0.319
Overall R-squared	0.133	0.115	0.010	0.005	0.401	0.425	0.363	0.330	0.280	0.272

Notes: Robust standard errors in parentheses; *** $p<0.01$, ** $p<0.05$, * $p<0.1$.

Table 4 Estimation results for the effect of rural e-commerce on crude birth rates

VARIABLES	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
	FE		FE-IV		Dynamic FE		Dynamic FE-IV		GMM	
Taobao village	-0.001*		-0.010**		-0.001**		-0.005**		-0.001	
	(0.001)		(0.004)		(0.001)		(0.002)		(0.001)	
ln(the number of Taobao villages)		-0.001***		-0.002***		-0.001***		-0.001*		-0.001*
		(0.000)		(0.001)		(0.000)		(0.001)		(0.000)
Lagged crude birth rate					0.207***	0.163**	0.202***	0.154**	0.484***	0.474***
					(0.065)	(0.062)	(0.072)	(0.072)	(0.061)	(0.059)
Control variables	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Constant	1.427***	1.514***	2.497***	1.598***	1.821***	1.906***	2.222***	1.955***	0.791***	0.772***
	(0.285)	(0.275)	(0.550)	(0.323)	(0.315)	(0.288)	(0.388)	(0.337)	(0.229)	(0.220)
Observations	369	369	369	369	328	328	328	328	287	287
Number of county_id	41	41	41	41	41	41	41	41	41	41
First stage regression										
IV										
ln(the number of mobile phone subscribers in cities ten years ago)			0.421**	1.799***			0.323	1.643***		
			(0.170)	(0.463)			(0.214)	(0.406)		
Cragg-Donald Wald F statistic			8.581	43.248			9.847	41.134		
Kleibergen-Paap rk Wald F statistic			9.374	39.570			10.551	33.896		
AR(1) test									0.002	0.001
AR(2) test									0.107	0.083

Within R-squared	0.484	0.508		0.458	0.623	0.638	0.549	0.637
Between R-squared	0.318	0.319	0.162	0.230	0.061	0.014	0.092	0.007
Overall R-squared	0.280	0.272	0.138	0.202	0.000	0.026	0.000	0.041

Notes: Robust standard errors in parentheses; *** $p<0.01$, ** $p<0.05$, * $p<0.1$.

Table 5 Estimation results using subsamples (Subei, Suzhong, and Sunan)

	(1)	(2)	(3)	(4)	(5)	(6)
	Subei		Suzhong		Sunan	
VARIABLES	FE					
Taobao village	-0.002		-0.001		-0.001	
	(0.001)		(0.000)		(0.001)	
ln(the number of Taobao villages)		-0.001***		-0.001***		-0.001
		(0.000)		(0.000)		(0.001)
Control variables	Yes	Yes	Yes	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Constant	2.737***	2.386***	1.513***	1.447***	1.111	2.203
	(0.721)	(0.738)	(0.467)	(0.271)	(1.182)	(1.664)
Observations	180	180	99	99	90	90
Number of county_id	20	20	11	11	10	10
Within R-squared	0.674	0.687	0.623	0.644	0.238	0.261
Between R-squared	0.365	0.378	0.058	0.056	0.032	0.029
Overall R-squared	0.411	0.435	0.192	0.191	0.004	0.003

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

Table 6 Heterogeneous effects of rural e-commerce development on crude birth rates

VARIABLES	(1)	(2)	(3)	(4)	(5)	(6)
			FE			
Taobao village	0.003**		-0.044*		-0.039***	
	(0.001)		(0.024)		(0.011)	
ln(the number of Taobao villages)		0.001**		-0.034***		-0.024***
		(0.001)		(0.008)		(0.005)
ln(real rural income per capita)			-0.020	-0.015		
			(0.013)	(0.010)		
ln(real GDP per capita)	-0.061*	-0.045			0.001	-0.000
	(0.033)	(0.033)			(0.004)	(0.004)
ln(squared of real GDP per capita)	0.003*	0.002				
	(0.001)	(0.001)				
the ratio of employment of primary sector	0.021**	0.020**	0.021**	0.020**	0.020**	0.019**
	(0.008)	(0.008)	(0.008)	(0.008)	(0.008)	(0.008)
Taobao Village#the ratio of employment of primary sector	-0.013***					
	(0.004)					
ln(the number of Taobao Villages)#the ratio of employment of primary sector		-0.009***				
		(0.002)				
Taobao Village#ln(real rural income per capita)			0.004*			
			(0.002)			
ln(the number of Taobao Villages)#ln(real rural income per capita)				0.003***		
				(0.001)		
Taobao Village#ln(real GDP per capita)					0.003***	
					(0.001)	
ln(the number of Taobao Villages)#ln(real GDP per capita)						0.002***
						(0.000)

Control variables	Yes	Yes	Yes	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Constant	0.415**	0.361*	0.283**	0.262***	0.075	0.127**
	(0.188)	(0.195)	(0.119)	(0.088)	(0.056)	(0.057)
Joint significance test (p-value)	0.001	0.000	0.067	0.000	0.004	0.000
Observations	369	369	369	369	369	369
Number of county_id	41	41	41	41	41	41
Within R-squared	0.468	0.503	0.450	0.491	0.451	0.489
Between R-squared	0.203	0.232	0.365	0.327	0.184	0.239
Overall R-squared	0.249	0.258	0.292	0.275	0.241	0.262

Notes: Robust standard errors in parentheses; *** $p<0.01$, ** $p<0.05$, * $p<0.1$.

Table 7 Effects of rural e-commerce development on crude birth rates considering the influences of prior CBR

VARIABLES	(1) FE	(2) FE
Taobao village	0.003**	
	(0.001)	
ln(the number of Taobao villages)		0.000
		(0.000)
fertility three years ago	-0.146*	-0.211***
	(0.084)	(0.064)
Taobao Village#fertility three years ago	-0.287***	
	(0.063)	
ln(the number of Taobao Villages)#fertility three years ago		-0.104***
		(0.022)
Control variables	Yes	Yes
Year fixed effects	Yes	Yes
Constant	1.411***	1.490***
	(0.317)	(0.304)
Joint significance test (p-value)	0.006	0.000
Observations	369	369
Number of county_id	41	41
Within R-squared	0.398	0.429
Between R-squared	0.230	0.246
Overall R-squared	0.199	0.211

Notes: Robust standard errors in parentheses; *** $p<0.01$, ** $p<0.05$, * $p<0.1$.

Appendix Table A1 Literature review (China)

Literature	Unit	Data	Dependent variable	Main findings
Cai (2010)	County (cross-section)	provincial statistical yearbook and the 2000 census	TFR	[Positive] None [Negative] Policy, GDP per capita, FDI per capita, net migration
Li and Zhang (2008)	Province (cross-section)	statistical yearbook	CBR	[Positive] Child-age dependency rate [Negative] Elderly dependency rate, salary per employee
Poston (2000)	County and province (cross-section)	the 1982 and 1990 census	TFR and CBR	[Positive] Infant mortality rate, illiteracy rate [Negative] National income per capita, percentage of labor force in industrial occupations
Wang et al. (2016)	Province (panel)	statistical yearbook	CBR	[Positive] GDP per capita [Negative] Family planning policy, social security
Yang et al. (2013)	Province (panel)	statistical yearbook	CBR	[Positive] GDP per capita [Negative] Government's expenditure on education

Appendix Table A2 Variance inflation factor (VIF)

Independent variables	VIF
Taobao village dummy	3.16
the number of Taobao village	3.68
ln(population density)	2.66
ln(the number of enrolled students in regular secondary school (per 100000 persons))	3.52
ln(the number of health institutions)	1.75
ln(amount of foreign capital actually used)	2.15
the ratio of government expenditure to GDP	4.88
ln(real rural income per capita)	5343.4
ln(squared term of real rural income per capita)	5356.99
the ratio of employment of primary sector	6.67
the ratio of rural employment of tertiary sector	1.58
ln(average living space of rural residents)	2.38
female population ratio	4.79
migration ratio	9.47
ln(real GDP per capita)	22.8

Appendix Table A3-1 Summary statistics (full sample)

Variable	Obs	Mean	Std. Dev.	Min	Max
crude birth rate	369	0.011	0.005	0.003	0.029
Taobao village dummy	369	0.339	0.474	0	1
the number of Taobao village	369	3.317	11.589	0	112
population density	369	680.632	326.018	237.661	1791
the number of enrolled students in regular secondary school (per 100000 persons)	369	4194.903	1181.794	1953.397	8085.207
the number of health institutions	369	406.488	158.931	71	947
amount of foreign capital actually used	369	243.522	212.020	3.181	1147.425
the ratio of government expenditure to GDP	369	0.126	0.04	0.058	0.216
real rural income per capita	369	15420.250	4788.112	7451.000	30242.980
real GDP per capita	369	70959.100	40532.790	19867.000	202637.700
the ratio of employment of primary sector	369	0.252	0.118	0.013	0.588
the ratio of rural employment of tertiary sector	369	0.241	0.073	0.12	0.415
average living space of rural residents	369	54.696	10.756	33.021	83.100
female population ratio	369	0.492	0.014	0.462	0.518
migration ratio	369	-0.091	0.208	-0.411	0.564

Appendix Table A3-2 Summary statistics (with Taobao villages)

Variable	Obs	Mean	Std. Dev.	Min	Max
crude birth rate	125	0.011	0.005	0.003	0.026
Taobao village dummy	125	1	0	1	1
the number of Taobao village	125	9.792	18.294	1.000	112.000
population density	125	783.771	383.645	305.000	1791.000
the number of enrolled students in regular secondary school (per 100000 persons)	125	4039.266	1175.193	2405.623	7662.123
the number of health institutions	125	466.512	150.235	136.000	794.000
amount of foreign capital actually used	125	250.160	193.809	4.453	787.317
the ratio of government expenditure to GDP	125	0.116	0.036	0.058	0.206
real rural income per capita	125	18458.120	5354.936	10161.100	30242.980
real GDP per capita	125	89130.010	47916.840	33493.600	202637.700
the ratio of employment of primary sector	125	0.219	0.124	0.013	0.463
the ratio of rural employment of tertiary sector	125	0.224	0.067	0.133	0.412
average living space of rural residents	125	57.865	9.913	41.311	78.300
female population ratio	125	0.494	0.015	0.471	0.518
migration ratio	125	-0.051	0.247	-0.411	0.534

Appendix Table A3-3 Summary statistics (without Taobao villages)

Variable	Obs	Mean	Std. dev.	Min	Max
crude birth rate	244	0.011	0.005	0.004	0.029
Taobao village dummy	244	0	0	0	0
the number of Taobao village	244	0	0	0	0
population density	244	627.795	278.533	237.661	1763.412
the number of enrolled students in regular secondary school (per 100000 persons)	244	4274.635	1179.610	1953.397	8085.207
the number of health institutions	244	375.738	154.700	71.000	947.000
amount of foreign capital actually used	244	240.122	221.076	3.181	1147.425
the ratio of government expenditure to GDP	244	0.131	0.041	0.058	0.216
real rural income per capita	244	13863.970	3592.678	7451.000	25669.040
real GDP per capita	244	61650.240	32550.460	19867.000	169515.800
the ratio of employment of primary sector	244	0.268	0.112	0.016	0.588
the ratio of rural employment of tertiary sector	244	0.249	0.074	0.120	0.415
average living space of rural residents	244	53.073	10.828	33.021	83.100
female population ratio	244	0.491	0.013	0.462	0.515
migration ratio	244	-0.111	0.182	-0.361	0.564

Appendix Table A4 Estimation results before and after the one-child policy change

	(1)	(2)	(3)	(4)
	2011-2015		2016-2019	
VARIABLES	FE			
Taobao village	-0.000		0.001	
	(0.001)		(0.001)	
ln(the number of Taobao villages)		-0.001**		0.001
		(0.001)		(0.000)
Control variables				
Constant	1.120**	1.595***	1.111	1.070
	(0.461)	(0.545)	(0.886)	(0.863)
Observations	205	205	164	164
Number of county_id	41	41	41	41
Within R-squared	0.458	0.476	0.378	0.381
Between R-squared	0.356	0.330	0.028	0.032
Overall R-squared	0.310	0.289	0.006	0.007

Notes: Robust standard errors in parentheses; *** $p<0.01$, ** $p<0.05$, * $p<0.1$

Appendix Table A5 Estimation results of heterogeneous effects of the one-child policy change

VARIABLES	(1)	(2)
	FE	
Taobao village	-0.001	
	(0.001)	
ln(the number of Taobao villages)		-0.001***
		(0.000)
Policy relaxation	-0.000	-0.001
	(0.001)	(0.001)
Taobao Village#Policy relaxation	-0.002	
	(0.001)	
ln(the number of Taobao Villages)#Policy relaxation		-0.000
		(0.000)
Control variables	Yes	Yes
Year fixed effects	Yes	Yes
Constant	1.411***	1.490***
	(0.317)	(0.304)
Joint significance test (p-value)	0.006	0.000
Observations	369	369
Number of county_id	41	41
Within R-squared	0.398	0.429
Between R-squared	0.230	0.246
Overall R-squared	0.199	0.211

Notes: Robust standard errors in parentheses; *** $p<0.01$, ** $p<0.05$, * $p<0.1$