Impacts of capital intensity on family formation and gender equality in Vietnam

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Abstract: We examine whether changes in capital intensity from Vietnamese firms during 1999-2019 influence family formation and gender inequality, using panel data of communes. We use the recorded trajectories of cyclones to create a damage index as an instrumental variable. We find that higher capital intensity is associated with a higher share of single people and a lower share of families with multiple generations living together. Also, women prepared for high capital intensity industries by increasing their educational attainment. However, the results also indicate the sex ratio at birth is more skewed in communes with high capital intensity.

Keywords: Capital intensity, Gender inequality, Family formation, Cyclones, Vietnam

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1. Introduction

In the US, it took many decades before women achieved the levels of labor force participation seen today. This "quiet revolution" began when women born in the 1940s realized that their lives would be substantially different from those of previous generations (Goldin, 2006). Goldin (2006) indicates that later-born cohorts of women prepared for their future by investing more in their own human capital, for example, courses that helped them to close the gap with their male counterparts in terms of math and reading scores. However, it is not clear what specific economic factors led to the quiet revolution. Also, to our knowledge, no previous studies have investigated the potential for women in developing countries to follow a similar path and the factors that may trigger a similar revolution today.

Against this backdrop, we hypothesized that capital intensity would be an important economic factor leading to such a revolution. Capital intensity is often used in neo-classical growth models such as those of Solow and Ramsey to explain economic growth and differences in income per capita across countries. Derived from the Cobb–Douglas production function, capital intensity is the ratio between two inputs, namely, capital and labor. High capital intensity is often associated with technological advancement and innovation. High capital intensity also requires higher levels of human capital as well as the skills to handle more advanced technology.

Our hypothesis is derived from the literature on the impacts of production technologies on gender inequality. Some technologies are associated with specific gender-related absolute advantages such as physical strength; for example, the plow (Alesina, Giuliano, and Nunn, 2013) favors men. Meanwhile, studies in China reported comparative advantages in tea and cotton production for women (Qian, 2008; Xue, 2021). We argue that as capital intensity increases, the demand for advanced skills with fewer gender-specific requirements would lead to a revolution that reduces gender inequality.

We seek empirical evidence for possible influences of capital intensity on gender equality and family formation (i.e., marriage and number of generations in the family[1]) in a developing country, namely, Vietnam. We choose Vietnam because of some appealing facts. Vietnam has shown a high rate of growth in gross domestic product over the last three decades, averaging 6.5% per year, while the fertility rate has declined substantially, from 3.6 in 1990 to 1.95 in 2019.[2] The World Economic Forum's Global Gender Gap Reports ranked Vietnam at 41st, 33rd, and 31st in the world in terms of economic participation and opportunity for women in 2015, 2017, and 2020, respectively.[3] In addition, the 2001 US–Vietnam bilateral trade agreement brought many workers from the informal sector into the formal sector (McCaig and Pavcnik, 2018), particularly in (unskilled) labor-intensive industries with high wage growth during the period 2000-2007 (Fukase, 2013) and lifted many households out of poverty (McCaig, 2011). Vu and Yamada (2018) show that the gender wage gap diminished between 2002 and 2014. However, the World Economic Forum ranked Vietnam at the bottom in terms of survival health for females (139th, 138th, and 151st out of 145, 144, and 153 countries in 2015, 2017, and 2020, respectively) because of its highly skewed sex ratio at birth. These mixed facts on gender equality suggest a gap in the research on the casual impacts of economic development on family formation and gender equality.

In this paper, we examine whether the changes in capital intensity of firms aggregated at the Vietnamese commune level[4] are associated with changes in family formation schemes and gender equality within the commune. We examine the outcomes during the period from 1999 to 2019. We combine the Population and Housing Census of Vietnam in 1999, 2009, and 2019 with censuses of firms (information from 2000, 2006, and 2016) to obtain panel data on Vietnamese communes. We use the instrumental variable (IV) approach to identify the causal effect of capital intensity on the outcomes. The IV is the cyclone damage index for each

[1] The connection between the "revolution" and family formation would be strong. Giuliano (2010) notes that strong family ties are associated with larger family size and a reliance on unequal division of household work between male and female family members (i.e., the "male-breadwinner hypothesis").

[2] See Appendix 15.

[3] Source: https://www.weforum.org/publications/series/global-gender-gap-report/

[4] Commune is the official third-level administrative division in Vietnam, after province and district. In 2009, Vietnam had approximately 63 provinces, 689 districts, and 11,065 communes. The average commune has an area of 29.97 km^2 and a population of 13,131 people. Estimations using commune as a unit have a higher resolution than using a 0.25° gridded degree area because 0.25° gridded degree near the equator is about 27.75 km.

commune. We take advantage of the exogenous traces of cyclones and their wind strength in order to construct the damage index for each 5-year period prior to the censuses of firms.

Our estimation results indicate that high capital intensity is associated with a higher share of people remaining single relative to those who marry. We find that the share of families with multiple generations living together—as is traditional in Vietnam—is negatively associated with high capital intensity. We also find that high capital intensity leads to mixed results regarding gender equality. High capital intensity is associated with a higher probability of skewed sex ratio among children under 5 years of age, which leads to a decrease in gender equality. The opportunity costs of having additional children in order to obtain a boy under the son preference would be higher in communes where the capital intensity is high. Therefore, parents are more likely engage in sex selection to obtain the desired gender, thereby increasing the sex ratio. In contrast, high capital intensity is associated with lower probability of school dropouts among girls aged 15-17 years compared with their male peers. Also, girls are more likely than boys to complete junior high school. The results are consistent among people living in communes for more than 5 years. High capital intensity also attracts incoming migrants of prime working age (23-55 years)[5] with higher educational attainment, particularly women.

Our study contributes to the literature in several aspects. To our knowledge, this study is among the few to provide empirical evidence regarding the impacts of economic development, specifically, the effects of capital intensity on family formation and gender equality. Our study provides further explanation for the revolution in gender equality as described by Goldin (2006) as well as empirical evidence regarding the cause of some stylized facts related to structural changes and the family (e.g., decline in marriage and household size, increase in educational attainment) as modeled in Greenwood, Guner, and Marto (2023). Our study extends the literature on the impacts of production technologies on gender equality (e.g., Qian, 2008; Alesina, Giuliano, and Nunn, 2013) and family formation in contemporary Vietnamese society. Our study also suggests the application of a new IV—the cyclone damage index—for economic variables.

[5] As of the end of 2020, under Vietnamese law, the retirement age for men is 60 years while that for women is 55 years.

The remainder of this paper is organized as follows. Section 2 provides the background of our study. Section 3 describes the data as well as the construction of the cyclone damage index. Section 4 explains the methodology and the identification strategy. Section 5 reports and discusses the results, and Section 6 concludes the paper.

2. Background

The literature on family economics and gender equality is closely related to our study. In this section, we review the most important research from which our study is derived and developed.

Technological advancements and economic factors

Production technologies can create and change gender inequality. In particular, some production technologies may favor the labor force participation of one gender over the other. Alesina, Giuliano, and Nunn (2013) find that early agricultural technology had a strong influence on gender norms. For example, the invention of the plow resulted in a culture that favored men over women because men had an absolute advantage in terms of physical strength, which was needed to use the plow. Qian (2008) finds the survival rate of Chinese women was higher when they could earn higher incomes from female-enabling industries such as tea production, assuming that the income of men was constant. Similarly, Xue (2021) shows the rising value of cotton (1300-1840 CE) in China led to less sex selection, lower dowries, and female empowerment in a continuous manner. This was because women played an important role in cotton production and were major income earners in the family as a result of absolute and comparative advantages such as adroitness and persistence instead of physical strength (Xue, 2021).

However, with applications increased adoption of automation and information technologies, new emerging industries in contemporary society (i.e., services) and specific professionals (i.e., managers) might not require physical strength or gender-specific skills (in terms of both absolute and comparative advantages) and therefore depart from (local) natural conditions. Black and Juhn (2000) report that the number of women in professional and managerial positions in the US in the 1980s and 1990s was a response to the increased demand for skilled workers and the accompanying higher wages. However, it remains unclear what factors have the potential to ignite a revolution that causes girls and women to alter their life course in contemporary (future) society.

Advancements in technology gave women effective contraceptive methods that enabled them to plan their future. The advent of oral contraceptives contributed to the change in career paths for American women in the 1960s and 1970s, leading to increased wages for women in their 30s and 40s (Goldin and Katz, 2002; Bailey, 2006; Bailey, Hershbein, and Miller, 2012). However, "the pill" had no direct influence on cohorts younger than 18-20 years in the US. Rather, it was a tool with which women could achieve their objectives, not a motivation for revolution. Furthermore, whether the pill or other effective and inexpensive contraceptive methods might lead to greater investment in education for girls under the age of 18 years needs to be investigated with caution, perhaps as a new research agenda.

Economic incentives for family formation and division of household labor

From the perspective of economists, families form when the potential utility (from production and consumption) gained from formation outweighs remaining single, an idea that may date back to Becker (1991). Potential economic incentives for marriage include the division of household labor to exploit the comparative advantages of family members while sharing collective goods such as housing (Weiss, 1997). According to Grossbard-Shechtman (1984), the decisions of husbands and wives regarding labor supply should be jointly made. In addition, the incentive can also be considered risk pooling to secure consumption, for example, in the event that one or the other is unemployed (Weiss, 1997).

However, if marriage made people worse off, they would be reluctant to marry in the first place. For example, Bertrand, Kamenica, and Pan (2015) suggest that the marriage rate would decrease if women's incomes were higher than those of men. This is because when the wife outperforms the husband in the labor market, it is associated with low marital satisfaction and a higher probability of divorce. Still, to date, little empirical evidence has been reported regarding the linkage between capital intensity and family formation (gender equality).

Other factors

Beyond the scope of economic factors, culture (norms), institutions, and policies can also play a role in fomenting or suppressing revolution. Regulations (e.g., informal institutions co-existing within culture and norms) on family formation, lineage, and breakup, including marriage transfers, number of spouses, location of marriage, kinship, inheritance, and how assets are divided after divorce, can shape and help to maintain gender inequality (Anderson

and Bidner, 2023).[6] Culture, which includes beliefs and social norms as well as racial, religious, and social groups, also plays an important role. Culture remains relatively constant over time,[7] and is transferred from generation to generation but can vary greatly depending on the geographic boundaries (Bau and Fernandez, 2023).

However, such factors are often endogenous. For example, Bau and Fernandez (2023) note the following about the modern variation in developed countries with first and second demographic transitions: the first transition is related to decreasing fertility rate, mortality, and changes in the age of marriage, while the second transition is related to the low fertility rate (less than 2.1), delaying marriage, and unstable marital status or new family structure.[8] The origins of these transitions are difficult to disentangle because the changes are related to each other, as indicated by Guinnane (2011) in the case of fertility transition. This suggests the importance of using causal inference methods to identify any possible effects and overcome issues of endogeneity.

3. Data

We use three main data sources to construct a balanced panel of Vietnamese commune data for our analyses. The first dataset is the Population and Housing Census conducted in April of 1999, 2009, and 2019. For each commune, we calculate indicators proxied for family formation and gender inequality as the main outcomes. The main indicators per commune are ratios of households having one, two, or three or more generations[9] living together among all households; the ratio of single people to married people; the sex ratio among children aged under 5 years of age; the school dropout ratio of the population aged 15-17 years; and the ratio of the population that completed junior high school, high school, or university. We further

[6] See Anderson and Bidner (2023) for a detailed review on each issue.

[7] Bau and Fernandez (2023) also report cases in which culture has been influenced by sudden changes in technologies, institutions, and knowledge, causing incentives to behave in conventional ways to disappear.

[8] See Bau and Fernandez (2023) for a detailed review.

[9] We divide families into dummies based on the number of relationships to the household head: spouse, child, grandchild, parent, grandparent, and other. If a family has zero or "spouse" for the relationships to the household head, we classify it as a one-generation family. If a family has two different types of relationship such as "spouse" and "child," we classify it as a two-generation family. The three-generation-or-more family dummy is constructed in a similar way.

examine the outcomes according to gender, time (i.e., whether people live in the commune for ≥5 years), and the relative ratio of females to males for the abovementioned indicators where appropriate.

The second dataset is the economic census conducted by the General Statistics Office of Vietnam in 2001[10], 2007, and 2017. The census collects information on active firms, including their performance in the year before the year of the census. We use and aggregate information on the capital (workers) of all firms located in the commune and take the logarithm of the results.[11] We finalize the calculation by using the logarithm of the ratio between capital and the number of workers to form our main explanatory variable—the capital intensity of each commune.

The third dataset is the *International Best Track Archive* from the National Centers for Environment Information of the National Oceanic and Atmospheric Administration in the US.[12] This dataset contains data on cyclone traces between 1994 and 2015. We use the cyclone routes and detailed information on the strength of the cyclone at its eye every 6 hours in order to estimate a 5-year index of the potential damage to building structures in commune j (H_{jT}) caused by strong winds from cyclones prior to the economic censuses. Previous studies have used this measure as a proxy for the cyclone damage index.

Specifically, following Naguib et al. (2022), the index H_{jT} for the 5-year period T and from the total of n cyclones can be written as

$$H_{jT} = \sum_{s=1}^{n} H_{js} = \sum_{s=1}^{n} \sum_{t=1}^{m_s} \Omega_{sjt}\,, \qquad (1)$$

where Ω_{sjt} is a measure of the extent to which the residents of commune j are negatively impacted by cyclone s in an observed record at time t.[13] As suggested by Yang (2008), Pelli and Tschopp (2017), and Naguib et al. (2022), the measure Ω_{sjt} is the square of windspeed

[10] The GSO conducted the first economic census (often referred to as the 2001 census of enterprises) in 2001 to collect information on firms in 2000.

[11] We use the adjusted value X as in $lnX = ln(x + (x\text{^}2 + 1)\text{^}(1/2))$ when we aggregate capital (labor) as a raw value of x at the commune level in order to deal with the problem that some communes have no firms.

[12] The data are available from https://www.ncei.noaa.gov/products/international-best-track-archive.

[13] In general, a cyclone trace is recorded every 6-hour period (for example, for m_s times) until it subsides.

(estimated at the centroid of the commune) above 33 knots[14] (or ≥17 m/s) normalized by the maximum value of this variable:

$$\Omega_{sjt} = \frac{(W_{sjt}-33)^2}{(W_s^{max}-33)^2} \text{ if } W_{sjt} \geq 33. \quad (2)$$

The windspeed at the centroid of each commune, W_{sjt}, is estimated by using the distance from each commune centroid to the cyclone eye, D_{sjt} (measured in nautical miles), and the windspeed w_{sjt} observed at the cyclone eye s at the measured time t as follows:

$$W_{sjt} = \begin{cases} w_{sjt} \times \left(\frac{26.9978}{D_{sjt}}\right)^{0.5}, \ if\ D_{sjt} > 26.9978 \\ w_{sjt} \times \frac{D_{sjt}}{26.9978}, \ if\ D_{sjt} \leq 26.9978 \end{cases}. \quad (3)$$

Equation (3)[15] and the value 26.9978 follow Naguib et al. (2022), which is based on Deppermann (1947), Simpson & Riehl (1981), and Hsu & Zhongde (1998).

Finally, we combine the three types of data by commune and for the three periods (1999, 2009, and 2019). A detailed statistical description is presented in Appendix 1.

4. Methods, identification strategy, and econometric specification

We aim to estimate the impact of capital intensity (β) on outcomes in panel data of commune i at three different times (t). The general reduced-form equation of interest is as follows.

$$Outcome_{it} = \beta \times ln(K/L)_{it} + i + t + \varepsilon_{it} \quad (4)$$

Equation (4) uses a commune fixed effect (i) and a time fixed effect (t) but this faces two potential issues. The first is reverse causality; that is, the outcome causes the observed differences in capital intensity. However, the outcomes are from data collected in 1999, 2009,

[14] According to the literature, 33 knots (17 m/s) is often considered the minimum wind speed at which damage can occur. One knot equals 1 nautical mile (1.852 km) per hour.

[15] Wind speed accelerates to maximum speed and falls sharply. Naguib et al. (2022) note that 26.9978 is the Simpson and Riehl radius of maximum wind speed (measured in nautical miles). Ideally, the Simpson and Riehl radius of maximum wind speed should be estimated from differences in barometric pressure between the center and outer part of the cyclones. However, because the best track data have many missing values for barometric pressure, Naguib et al. (2022) use the average radius of maximum windspeed and apply it to every cyclone. We assume that 26.9978 nautical miles (or 50 km) also applies to our selected data.

and 2019, which were after the time when capital intensity measures had been collected in many cases. Therefore, this problem is not so likely in our analyses. The second issue is the endogeneity of capital intensity. There might be an association of capital intensity with some omitted variables in ε_{it}, which jointly decides the outcomes (i.e., demographic structure and social norms). Therefore, we need a valid time-varying IV to claim the causal effect from the capital intensity to the outcomes. Specifically, we need an IV that can explain the capital intensity and satisfy both the exclusion and exogeneity conditions.

The index for damage by cyclones per commune, H_{jT} (or H_{it} per equation 5), satisfies all the above conditions for several reasons. First, cyclone tracks are exogenous to local people and businesses. Specifically, the changes (strength) in cyclone tracks over time are exogenous. In addition, firms with high capital intensity in Vietnam alone are least likely to be able to influence the cyclones' tracks, although the firms may contribute to global climate change, which could lead to irregular cyclones.

Second, the changes in the index for damage by cyclones per commune would not directly affect family formation (marital status and number of generations living in the family) and gender equality. If they did, we would not be able to observe, perhaps, stable norms over centuries prior to our period of interest (1999-2019). As suggested by Vu and Yamada (forthcoming), our construction of outcomes for equality considers the relative gender ratio in outcomes; therefore, a direct impact of cyclones on the outcomes is highly unlikely.

There are several additional supporting arguments. Although child marriage varies with weather shocks in Sub-Saharan Africa and India (Corno, Hildebrandt, and Voena, 2020) because of marriage transfers, this is less likely to occur in Vietnam because of strict family registration regulations and laws prohibiting girls under the age of 18 years from marrying. Also, excessive marriage transfers (bride price) are not required. In the selected sample, the number of households with girls under the age of 18 years who are the household head with their spouse or the household head's spouse is less than 5 per 10,000 households (as shown in Appendix 1). We further examine the relationship between the cyclone damage index and the ratio of households with child marriage (where the wife is younger than 18 years of age) among all households in the commune. As shown in column 9 of Appendix 3, the negative relationship is counterintuitive with the possible mechanism and findings of Corno, Hildebrandt, and Voena (2020). We repeat similar exercises with sex ratio as the outcome (column 8 of Appendix 3)

and find another negative[16] and counterintuitive statistical result, which further strengthens our arguments on the exclusion condition of the IV.

In addition, tropical cyclones have limited impacts on labor outcomes. Karbownnik and Wray (2018) show that cyclones occurring during the important periods of fetal development and infancy affect future income via the health channel (due to disruption of the food supply and nutrition) but not labor supply. Other than these important periods, Karbownnik and Wray (2018) indicate that tropical cyclones have no significant effects in the long term.

We also examine the possibility that cyclones might directly drive people away through permanent migration and population displacement. Berlemann and Tran (2021) suggest that tropical storms induce more people to temporarily leave their homes, based on household data from the Vietnamese Household Living Standard Survey in 2012, 2014, and 2016. We perform a series of estimations, directly regressing different population cohorts—all, the elderly (age >64 years), children (age >10 years), prime working age adults (age 23-55 years), and long-term residents (living in the commune for more than 5 years)—on the cyclone damage index. As shown in columns 1-7 of Appendix 3, the cyclone damage index has either a statistically insignificant correlation or a positive correlation with all population sizes for each cohort. We repeat similar estimations with population density (per square kilometer) as the outcomes as in Appendix 4. The cyclone damage index does not show any statistically significant impacts on population density or the density of the prime working age population. Therefore, such (counterintuitive) evidence disproves the hypothesis of direct effects on (out-going) permanent migration and population displacement.

However, the index for cyclone damage per commune might intuitively be associated with capital intensity regarding mid-term and long-term perspectives.[17] For example, firms

[16] One may hypothesize that because of hard-hitting cyclones, parents may neglect their daughters or engage in sex selection due to a shortage of income, thereby potentially skewing the sex ratio.

[17] The accumulated damage index of cyclones over a period of 5 years is estimated to explain the capital intensity in the 6th year. In addition, we consider only the changes over every 10-year period with the commune fixed effects. Therefore, the coefficient of the damage index is less likely to capture the positive relationship between damage by cyclones and infrastructure repairs due to the damage (i.e., the high investment in reconstruction shortly after the cyclones leads to modified infrastructure designed to mitigate the effects of cyclones). This is because the headquarters of firms that repair infrastructure are not necessarily located in the commune and are the least likely to remain in the commune permanently. Government aid provided to compensate for cyclone damage (if any) is not very likely to change existing firms' capital intensity, nor is there a higher probability of it to capture the temporary economic slowdown due to direct hit of the cyclone.

with higher capital intensity are less likely to risk locating their assets (e.g., plants, factories, stores) in areas prone to cyclones. If they did, they would reconsider and reallocate elsewhere after first experiencing the impacts of cyclone damage. In the extreme case, the firms would exit. As shown in Appendix 13, changes in the number of firms located in the commune have a negative nexus with cyclone damage, which is evidence of reallocation (exit) or a low probability of new firms locating in the affected communes.

In addition, Vietnam has a long coastline and is prone to tropical cyclones (as shown in Figure 1). Of the 7,763 communes in our sample, 6,903 are subject to at least some potential cyclone damage from strong wind in the periods 1994-1998, 2001-2005, and 2011-2015.

Therefore, in the first stage, we estimate

$$ln(K/L)_{it} = \alpha \times H_{it} + i + t \ + \epsilon_{it}. \quad (5)$$

Specifically, we use H_{it} in the periods of 1995-1999, 2001-2005, and 2011-2015 to explain the capital intensity of each commune i measured in the 2000, 2006, and 2016 economic censuses, respectively. We note that equation (5) uses commune fixed effects (i). The climate and the constant risk to cyclones are captured in the commune fixed effects. The time fixed effect (t) combined with the commune fixed effects (i) help to identify idiosyncratic local shocks (Dell, Jones, and Olken, 2014). The equation considers only changes in H_{it} that impact changes in capital intensity. We use the predicted value of capital intensity from equation (5) to estimate β in equation (4), using district clustered standard errors. The simple correlation checks, which are similar to the first stage (equation 5) in Appendix 2, shows a statistically significant negative association between H_{it} and $ln(K/L)_{it}$ (−0.023).

5. Results

5.1 Family formation

We find that capital intensity affects family formation within the commune. Specifically, capital intensity reduces the proportion of households with two, three, or more generations living together, as shown in columns (2) and (3) of Table 1. Meanwhile, the proportion of single-generation households increases with higher capital intensity (column 1 of Table 1). This is because people tend to remain single (either temporarily or permanently) in communes where capital intensity is high. As shown in column 4 of Table 1, higher capital intensity is associated with a higher ratio of single people to married people. This is true for both the male

and female populations in our two separate estimations in columns 5 and 6 in Table 1. The results suggest that family ties become weaker, a phenomenon that is likely to accelerate in the future, thereby helping to increase gender equality. This is because Alesina and Giuliano (2010) show that strong family ties are associated with larger family size, higher home production, lower labor force participation of women and young people, and lower geographical mobility.

[Insert Table 1 here]

A potential mechanism may lie in the tendency for high capital intensity to be associated with industries having formal employment and perhaps higher wages, particularly among young people. Vietnamese have strong family ties (Alesina and Giuliano, 2014). The traditional family formation in which multiple generations live together may function as a kind of insurance and buffer against risk. However, workers with formal employment and perhaps higher wages may no longer need to adhere to such traditions. When wages are higher, people might want to delay marriage. This is because people need to accumulate more human capital such as education and training to get a job at a firm with higher capital intensity. In addition, the findings of Bertrand, Kamenica, and Pan (2015) suggest that the marriage rate would decline if women earned more than men, assuming that both are randomly selected.

5.2 Gender equality

We find mixed results regarding gender equality. On the one hand, higher capital intensity is associated with a higher ratio of boys to girls under the age of 5 years (Table 2), that is more "missing women." Many factors may explain the phenomenon. Son preference is persistent in Vietnam (Vu, 2014). The non-economic value of boys also outweighs that of girls (Schultz, 1997). As Schultz (1997) suggests, only male children can carry on the family lineage and perform certain rituals after the parents pass away. Because there are no goods that can substitute the value of boys, parents would desperately pursue having a son. Meanwhile, capital intensity probably steers people away from marriage (as shown in columns 4, 5, and 6 of Table 1). Therefore, it is more likely that both men and women would delay having children. Also, high capital intensity may be associated with high income and increased opportunity costs of having more children in order to obtain a son. We note that the fertility rate of Vietnamese women has been well under 2.1 since 1999 (see Appendix 15). Thus, such parents would face

a higher time constraint compared with others.[18] They would engage in sex selection to minimize the opportunity costs of obtaining a son, skewing the sex ratio in the short run. However, in the long run, a skewed sex ratio might offset gender inequality because of the higher marriage market price for women in cohorts with a skewed sex ratio (Grossbard, 2015), particularly the bride price,[19] and may even shift the culture in favor of empowering women (Teso, 2019).

[Insert Table 2 here]

On the other hand, we find that high capital intensity is associated with a higher probability of having higher educational attainment, particularly for women. When capital intensity is high, more girls complete junior high school (as shown in column 3 of Table 3) and subsequently complete high school at higher rates compared with boys (as shown in column 6 of Table 3). This is because girls are motivated to learn at the ages of 15-17 years in association with higher capital intensity. Given that the school dropout rates for both boys and girls are negatively correlated with higher capital intensity (as shown in columns 1, 2, and 3 of Appendix 6), girls are less likely than boys to drop out of the school. It is likely that when capital intensity is high, girls prepare for jobs that require at least a junior high school education. We note that it is the girl who likely decides her own future. This is because of the parents' son preference. Because son preference is not merely sex selection, the parents who prefer sons may not invest adequately in unwanted daughters, as suggested by Jayachandran and Pande (2017) and Rastogi and Sharma (2022).

[Insert Table 3 here]

One explanation for women's efforts toward higher educational attainment might be that they have higher marginal returns to education compared with men. Vu and Yamada (2018) suggest that the wage gap between men and women narrowed during the period 2002-2014. In addition, women living in places where capital intensity is high might have more job opportunities compared with women living elsewhere (as shown in column 1 of Appendix 14).

[18] For example, such parents would have invested more time in their own education (we will present evidence for this below) and married later in life. In addition, these parents may want to increase the quality of their children (e.g., by investing more in their children's education) as their income rises.

[19] Wei and Zhang (2011) show that household saving rates are higher when the sex ratio is high. This is because of competition in the marriage market, reflecting the shortage of brides.

The results are consistent among people who live in the commune for 5 or more years, as shown in Table 4.[20] The results contribute to the literature on the revolution of female participation in the workforce, particularly in developing countries. In the early 2000s, labor-intensive industries attracted many Vietnamese workers away from informal sectors (Fukase, 2013). However, looking at a longer window of time, from 1999 to 2019, our estimation results suggest that women ultimately find high capital intensity industries attractive. And more importantly, they pursue higher education to be prepared for the labor market's requirements.

[Insert Table 4 here]

We further consider internal migration given that high capital intensity might also be attractive for such migration.[21] As shown in columns 1 and 2 of Table 5, higher capital intensity attracts more incoming migrants, especially women. A higher ratio of women to men is common among incoming migrants aged 23-55 years (column 3 of Table 5). Such evidence further supports our argument of an association between more job opportunities and higher capital intensity. The evidence suggests that women have already migrated in response to high capital intensity, although the rate of internal migration remains limited in general.

[Insert Table 5 here]

We also examine what educational attainment pattern is typical among incoming migrants in association with high capital intensity (Table 6). High capital intensity tends to attract incoming female migrants with at least a junior high school education. The results suggest a positive correlation between high capital intensity and the number of women with college degrees among incoming migrants (column 7 of Table 6). Women with a high school education are more likely than men to migrate to a commune with high capital intensity.

[Insert Table 6 here]

5.3 Which industries contribute to the revolution?

[20] The 2009 and 2019 data contain information on the duration of residence in its 15% and 10%population questionnaires, respectively, while the 1999 data contain information in its 100% population questionnaires. One question asks whether the person has been living in the commune for more than 5 years.

[21] We note that the proportion of incoming migrants aged 23-55 years among the commune population is rather small, 1.3% for women and 1% for men, as shown in Appendix 1.

We further examine what specific industries might contribute to the revolution, using a back-of-the-envelope calculation. We select some "female-enabling" industries such as food and beverages, textiles and garments, shoes and leather, trading, restaurants and hotels, information and communication technology, and health and aggregated the employment numbers and capital intensity over time and then compare them against those of the agriculture, forestry, and aquaculture industries (Figure 2). Industries with high capital intensity combined with high employment are very likely to be the main driving force. As shown in Figure 2, the driving industries might be trading, food and beverages (manufacturing), and restaurants and hotels. This calculation is in line with the relative level of female educational attainment estimated in Table 3. However, despite having high employment, shoes and leather (manufacturing), and even textiles and garments do not show an outstanding increase in capital intensity; therefore, these industries are not likely to provide the main leverage.

[Insert Figure 2 here]

5.4 Discussion

We note that many factors can have causal effects on the quiet revolution of Vietnamese women, and capital intensity is just one such factor. Other factors, including changes in public policy aimed at promoting gender equality and women's empowerment such as maternal health care, family planning (safe sex), land reform—women's right to jointly possess land-use rights with their husbands (Menon, Rodgers, and Nguyen, 2014; Nguyen and Le, 2023)—occurring in the same period might also contribute to the revolution. The legacy of communist ideology, which promotes women's inclusion in economic activities (Campa and Serafinelli, 2019), might also serve as a basis for the revolution. Nevertheless, we identify the causal impacts of capital intensity, based on temporal and regional variations in capital intensity and the IV approach (based on exogenous traces of cyclones and regional fixed effects).

Policy changes that aim to benefit both genders would not be a direct cause. For example, building more schools would facilitate the revolution by extending the supply of educational services. According to the Statistics Yearbooks of the General Statistics Office of Vietnam, the number of schools increased from 21,769 primary and junior high schools and 1,645 high schools in 1998 to 23,521 primary and junior high schools and 2,386 high schools in 2019. However, the increase in educational supply cannot be a direct cause for the revolution because it benefits both genders and it does not explain why boys pursue higher education at a slower rate compared with girls. Similarly, compulsory primary education might also facilitate

a higher attendance rate among girls in the 15-17-year of age group. However, the policy was applied nationwide at the same time, whereas our estimation relies on regional variations. Therefore, our estimated impacts of capital intensity are distinct from the possible influences of compulsory primary education.

Is there a potential ceiling for the revolution? As shown in column 9 of Table 3, capital intensity is associated with a lower share of women having college degrees compared with men living in the same commune. Similarly, as shown in column 3 of Appendix 14, capital intensity is negatively associated with the employment of women in firms compared with that of men. The reasons may lie on the labor supply side rather than the demand side. This is because we do not find any evidence for women with college degrees being disadvantaged compared with their male counterparts when migrating to other communes where capital intensity is high (columns 7 and 9 of Table 6). Although women prepare themselves by pursuing higher education, their preparation is perhaps slower than the speed of change in capital intensity. This is because the revolution needs to start from low educational attainment and proceed to higher educational attainment. Moreover, male-dominated industries do not die out when capital intensity rises. If such industries expand because of higher capital intensity and require more workers with tertiary education, the results described above might be the consequences. However, future research should be conducted when new data covering a longer period of time become available.

Although the gender wage gap due to differences in productive characteristics can be eliminated (Goldin, 2014), our findings should not be interpreted to suggest that gender equality worldwide will converge as technology progresses. As described above, many factors can decrease or increase gender equality within a given country. For example, the revolution might close the gap between men and women in terms of educational outcomes, as is now occurring in Japan. Japan is ranked high (47th) by the World Economic Forum in terms of the gender gap in educational attainment (a minimal gap[22]). However, it is ranked very low (123rd) in terms of economic participation and opportunity for women.[23]

[22] The World Bank reports that 62% of Japanese women and 63% of Japanese men were enrolled in tertiary education in 2020 (https://data.worldbank.org/indicator/SE.TER.ENRR.FE?locations=JP, https://data.worldbank.org/indicator/SE.TER.ENRR.MA?locations=JP).

[23] Source: https://www3.weforum.org/docs/WEF_GGGR_2023.pdf

6. Conclusions

We examined the impacts of capital intensity aggregated from censuses of formal firms located within communes on family formation and gender equality, using an IV approach. We found that the share of single people in the commune population increased with higher capital intensity, while the share of households with multiple generations living together decreased. Educational attainment among women increased relative to that among men in communes where capital intensity was high. However, we also found that the sex ratio among children under 5 years of age increases with high capital intensity. Perhaps the higher opportunity costs of having a son when income potentially rises would induce people to engage in sex selection in order to get obtain a son. Our results suggest that capital intensity is an important economic factor that contributed to the revolution of female participation in the labor force over the last 30 years in Vietnam.

However, our study also has some limitations. First, the earliest economic census was conducted after 2000; therefore, the direction between capital intensity and the main outcomes is the opposite of that for the first wave of the panel data examined. Second, our study lacks external validity because the IV relies on traces of cyclones. Third, where cyclones left severe damage, the government might have provided subsidies to compensate for the cyclones' impact. We lack data at the commune level to control for such remedies. Fourth, similarly, firms may learn from their experience with cyclones and relocate or build new assets in areas less vulnerable to cyclones. Therefore, the impacts of cyclones on capital intensity should not be strictly (and implicitly) assumed to be linear over time, as in our estimations. However, these limitations suggest that future studies should be conducted when detailed microdata on the environment become available thanks to more newly installed sensors.

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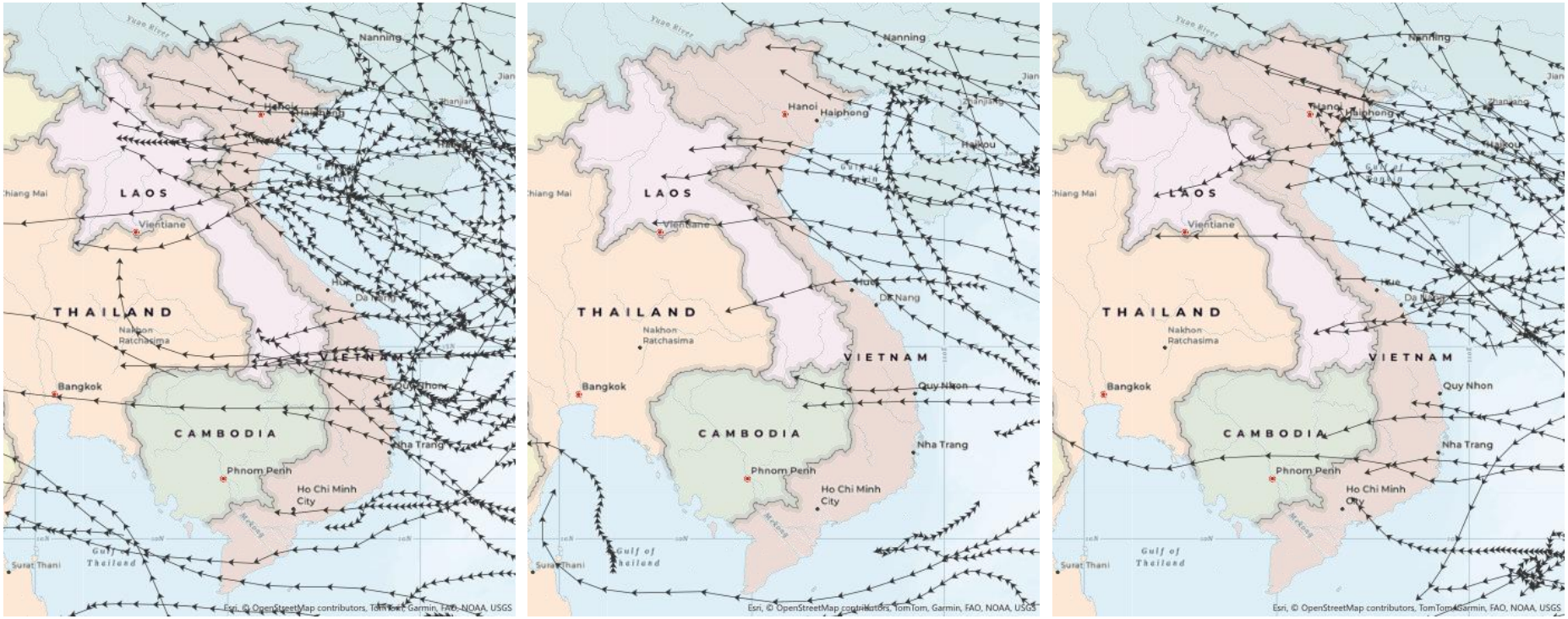
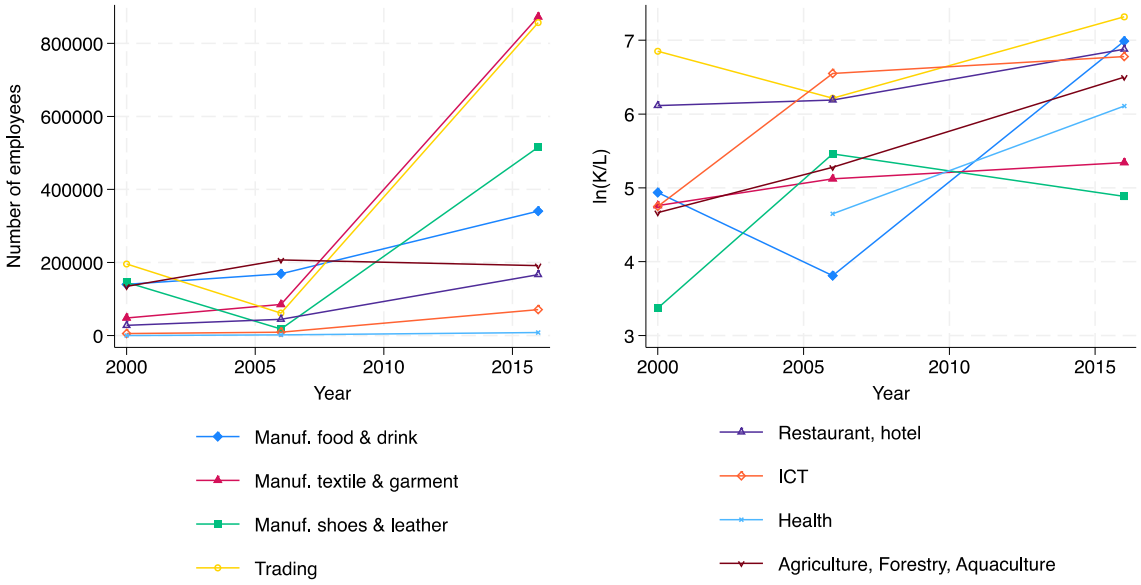
Figure 1. Cyclone eyes' trajectories in in-land territory of Vietnam



1994-1998 2001-2005 2011-2015

Note: The arrows indicate cyclones' eyes recorded in the *International Best Track Archive*.

Figure 2. Employment and capital intensity by female-enabled industry



Source: Authors' calculation from 7763 communes in the selected sample.

Table 1. Impacts of capital intensity on family formation

Variables	Ratio HHs having 1 generation among all HHs	Ratio HHs having 2 generations among all HHs	Ratio HHs having 3 generations or more among all HHs	All	Among males	Among females
				Single/Married	Single/Married	Single/Married
	(1)	(2)	(3)	(4)	(5)	(6)
ln(K/L)	0.0115***	−0.0085***	−0.0023*	0.0085***	0.0090***	0.0079***
	(0.0018)	(0.0013)	(0.0012)	(0.0015)	(0.0016)	(0.0015)
Year fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Commune fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
F-statistics in the first stage	105	105	105	105	105	49.79
Observations	23,289	23,289	23,289	23,289	23,289	23,289
Number of communes	7,763	7,763	7,763	7,763	7,763	7,763

Note: District-clustered robust standard errors in parentheses (*** p<0.01, ** p<0.05, * p<0.1).

Table 2. Capital intensity and sex ratio among population aged 0-4

VARIABLES	Sex ratio
	(1)
ln(K/L)	0.0065***
	(0.0014)
Year fixed effects	Yes
Commune fixed effects	Yes
F-statistics in the first stage	105
Observations	23,289
Number of communes	7,763

Note: District-clustered robust standard errors in parentheses (*** p<0.01, ** p<0.05, * p<0.1).

Table 3. Capital intensity and educational attainment among population aged 23-55

VARIABLES	Ratio of population completed junior high school (9-year) as the highest degree			Ratio of population completed high school (12-year) as highest the degree			Ratio of population having college degrees (4-5 years)		
	Females (F)	Males (M)	F/M	Females (F)	Males (M)	F/M	Females (F)	Males (M)	F/M
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
ln(K/L)	0.0115***	0.0089***	0.0192***	0.0019***	0.0001	0.0194***	0.0008***	0.0010***	−0.0929***
	(0.0012)	(0.0009)	(0.0049)	(0.0004)	(0.0004)	(0.0047)	(0.0002)	(0.0002)	(0.0122)
Year fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Commune fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
F-statistics in the first stage	105	105	104	105	105	104	105	105	90
Observations	23,289	23,289	23,277	23,289	23,289	23,269	23,289	23,289	22,927
Number of communes	7,763	7,763	7,763	7,763	7,763	7,763	7,763	7,763	7,763

Note: District-clustered robust standard errors in parentheses (*** p<0.01, ** p<0.05, * p<0.1).

Table 4. Capital intensity and educational attainment among population aged 23-55 who stayed in the commune for more than 5 years

VARIABLES	Ratio of population completed junior high school (9-year) as highest the degree			Ratio of population completed high school (12-year) as highest the degree			Ratio of population having college degrees (4-5 years)		
	Females (F)	Males (M)	F/M	Females (F)	Males (M)	F/M	Females (F)	Males (M)	F/M
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
ln(K/L)	0.0115***	0.0082***	0.0289***	0.0019***	−0.0005	0.0336***	0.0007***	0.0008***	−0.0929***
	(0.0012)	(0.0009)	(0.0067)	(0.0004)	(0.0004)	(0.0072)	(0.0002)	(0.0002)	(0.0122)
Year fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Commune fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
F-statistics in the first stage	105	105	101	105	105	100	105	105	90
Observations	23,289	23,289	23,185	23,289	23,289	23,116	23,289	23,289	22,927
Number of communes	7,763	7,763	7,756	7,763	7,763	7,754	7,763	7,763	7,763

Note: District-clustered robust standard errors in parentheses (*** p<0.01, ** p<0.05, * p<0.1).

Table 5. Impacts of capital intensity on incoming migrants aged 23-55

VARIABLES	Females (F)	Males (M)	F/M
	(1)	(2)	(3)
ln(K/L)	0.0008***	0.0005**	0.2303***
	(0.0002)	(0.0002)	(0.0309)
Year fixed effects	Yes	Yes	Yes
Commune fixed effects	Yes	Yes	Yes
F-statistics in the first stage	105	105	92
Observations	23,289	23,289	20,120
Number of communes	7,763	7,763	7,325

Note: District-clustered robust standard errors in parentheses (*** p<0.01, ** p<0.05, * p<0.1).

Table 6. Capital intensity and educational attainment among population aged 23-55 who moved in the commune for less than 5 years

VARIABLES	Ratio of population completed junior high school (9-year) as highest the degree			Ratio of population completed high school (12-year) as highest the degree			Ratio of population having college degrees (4-5 years)		
	Females (F)	Males (M)	F/M	Females (F)	Males (M)	F/M	Females (F)	Males (M)	F/M
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
ln(K/L)	0.0003***	0.0001*	0.1443***	0.0001**	−0.0000	0.0830***	0.0002**	−0.0000	0.0036
	(0.0001)	(0.0001)	(0.0373)	(0.0000)	(0.0001)	(0.0239)	(0.0001)	(0.0000)	(0.0211)
Year fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Commune fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
F-statistics in the first stage	105	105	62	105	105	66	105	105	45
Observations	23,289	23,289	13,773	23,289	23,289	12,951	23,289	23,289	10,366
Number of communes	7,763	7,763	5,695	7,763	7,763	5,314	7,763	7,763	4,255

Note: District-clustered robust standard errors in parentheses (*** p<0.01, ** p<0.05, * p<0.1).

Appendix 1. Descriptive statistics

Variables	N	Mean	SD	Min	Max
ln(K/L)	23,289	12.314	9.152	0.000	25.242
Cyclone damage	23,289	33.319	55.544	0.000	290.403
Ratio of 1-generation HHs among all HHs	23,289	0.143	0.091	0.000	0.868
Ratio of 2-generation HHs among all HHs	23,289	0.604	0.082	0.090	0.866
Ratio of 3-generation or more HHs among all HHs	23,289	0.245	0.092	0.015	0.772
Ratio of (male or female) singles among					
Married people	23,289	0.389	0.147	0.038	2.214
Married people (Males)	23,289	0.442	0.151	0.047	3.320
Married people (Females)	23,289	0.336	0.154	0.019	2.426
School dropout rate among 15-17					
years of age					
Females (F)	23,285	0.329	0.226	0.000	1.000
Males (M)	23,289	0.329	0.185	0.000	1.000
Relative ratio (F/M)	23,248	0.994	0.505	0.000	16.667
Sex ratio (M/F) among age 0-4	23,289	1.083	0.115	0.471	1.973
Ratio of HHs with child marriage among all HHs	23,289	0.00049	0.001	0.000	0.029
A. Aged 23-55 (All)					
Completed junior high school over commune population					
Females (F)	23,289	0.053	0.051	0.000	0.261
Males (M)	23,289	0.056	0.043	0.000	0.264
F/M	23,277	0.830	0.343	0.000	25.000
Completed high school over commune population					
Females (F)	23,289	0.043	0.036	0.000	0.199
Males (M)	23,289	0.049	0.032	0.000	0.189
F/M	23,269	0.783	0.334	0.000	9.000
Having college degree over commune population					
Females (F)	23,289	0.017	0.023	0.000	0.196
Males (M)	23,289	0.017	0.021	0.000	0.182
F/M	22,927	0.922	0.502	0.000	12.000

Appendix 1. Descriptive statistics (Cont.)

Variables	N	Mean	SD	Min	Max
B. Aged 23-55 and living more than 5 years					
Completed junior high school over commune population					
Females (F)	23,289	0.050	0.051	0.000	0.244
Males (M)	23,289	0.051	0.043	0.000	0.220
F/M	23,192	0.887	0.458	0.000	19.000
Completed high school over commune population					
Females (F)	23,289	0.038	0.034	0.000	0.211
Males (M)	23,289	0.041	0.029	0.000	0.214
F/M	23,125	0.837	0.451	0.000	8.000
Having college degree over commune population					
Females (F)	23,289	0.015	0.020	0.000	0.181
Males (M)	23,289	0.014	0.017	0.000	0.157
F/M	22,019	1.079	0.853	0.000	16.000
C. Aged 23-55 and living less than 5 years					
Over commune population					
Females (F)	23,289	0.013	0.015	0.000	0.254
Males (M)	23,289	0.010	0.015	0.000	0.239
F/M	20,555	1.943	2.235	0.000	37.000
Completed junior high school over commune population					
Females (F)	23,289	0.003	0.005	0.000	0.140
Males (M)	23,289	0.002	0.004	0.000	0.117
F/M	15,556	1.583	1.942	0.000	40.000
Completed high school over commune population					
Females (F)	23,289	0.003	0.004	0.000	0.086
Males (M)	23,289	0.002	0.004	0.000	0.082
F/M	15,267	1.220	1.673	0.000	97.000
Having college degree over commune population					
Females (F)	23,289	0.003	0.006	0.000	0.120
Males (M)	23,289	0.002	0.005	0.000	0.122
F/M	12,975	1.105	1.315	0.000	22.000

Appendix 2. Correlation between cyclone damage index and the capital intensity

VARIABLES	(1) ln(K/L)
Cyclone damage	−0.0232***
	(0.0023)
Year fixed effect	Yes
Commune fixed effect	Yes
R-squared	0.393
Number of communes	7,763
Observations	23,289

Appendix 3. Correlation between cyclone damage index and some outcomes

VARIABLES	Population	Population by age					Being 5 years or more in the commune	Sex ratio (< 5 years of age)	Ratio of household with child marriage
		< 10	> 64	23-55	23-55 (Male)	23-55 (Female)			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Cyclone damage	2.4628***	0.2599	−0.0560	2.0522***	1.0011***	1.0511***	0.0001***	−0.0002***	−0.0000***
	(0.7981)	(0.1879)	(0.0583)	(0.4674)	(0.2358)	(0.2336)	(0.0000)	(0.0000)	(0.0000)
Year fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Commune fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
R-squared	0.036	0.138	0.452	0.131	0.152	0.108	0.328	0.055	0.074
Observations	23,289	23,289	23,289	23,289	23,289	23,289	23,289	23,289	23,289
Number of commune	7,763	7,763	7,763	7,763	7,763	7,763	7,763	7,763	7,763

Note: District-clustered robust standard errors in parentheses (*** p<0.01, ** p<0.05, * p<0.1).

Appendix 4. Correlation between cyclone damage index and the population density per squared kilometer

		Age				
VARIABLES	All	< 10	> 64	23-55	23-55 (Male)	23-55 (Female)
	(1)	(2)	(3)	(4)	(5)	(6)
Cyclone damage	0.1384	0.1940***	−0.1212***	−0.0169	−0.0236	0.0067
	(0.2437)	(0.0743)	(0.0453)	(0.1295)	(0.0682)	(0.0627)
Year fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Commune fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
R-squared	0.000	0.014	0.054	0.005	0.005	0.005
Observations	23,289	23,289	23,289	23,289	23,289	23,289
Number of commune	7,763	7,763	7,763	7,763	7,763	7,763

Note: District-clustered robust standard errors in parentheses (*** p<0.01, ** p<0.05, * p<0.1).

Appendix 5. Capital intensity and the population density (per squared kilometer)

		Age				
VARIABLES	All	< 10	> 64	23-55	23-55 (Male)	23-55 (Female)
	(1)	(2)	(3)	(4)	(5)	(6)
ln(K/L)	−5.9550	−8.3476**	5.2135**	0.7282	1.0150	−0.2867
	(10.5438)	(3.4426)	(2.1912)	(5.5581)	(2.9210)	(2.6984)
Year fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Commune fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
F-statistics first stage	105	105	105	105	105	105
Number of commune	7,763	7,763	7,763	7,763	7,763	7,763
Observations	23,289	23,289	23,289	23,289	23,289	23,289

Note: District-clustered robust standard errors in parentheses (*** p<0.01, ** p<0.05, * p<0.1).

Appendix 6. Capital intensity and school dropouts among population aged 15-17

VARIABLES	School dropouts		
	Females (F)	Males (M)	F/M
	(1)	(2)	(3)
ln(K/L)	−0.0023***	−0.0009***	−0.0047***
	(0.0003)	(0.0002)	(0.0007)
Year fixed effects	Yes	Yes	Yes
Commune fixed effects	Yes	Yes	Yes
F-statistics first stage	105	105	105
R-squared	0.620	0.326	0.391
Observations	23,285	23,289	23,248
Number of communes	7,763	7,763	7,763

Note: District-clustered robust standard errors in parentheses (*** p<0.01, ** p<0.05, * p<0.1).

Appendix 7. Correlation between capital intensity and family formation

Variables	Ratio HHs having 1 generation among all HHs	Ratio HHs having 2 generations among all HHs	Ratio HHs having 3 generations or more among all HHs	All	Among males	Among females
				Single/Married	Single/Married	Single/Married
	(1)	(2)	(3)	(4)	(5)	(6)
ln(K/L)	0.0002**	−0.0002**	0.0001	0.0006***	0.0008***	0.0004***
	(0.0001)	(0.0001)	(0.0001)	(0.0001)	(0.0002)	(0.0001)
Year fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Commune fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
R-squared	0.719	0.606	0.181	0.746	0.654	0.756
Observations	23,289	23,289	23,289	23,289	23,289	23,289
Number of communes	7,763	7,763	7,763	7,763	7,763	7,763

Note: District-clustered robust standard errors in parentheses (*** p<0.01, ** p<0.05, * p<0.1).

Appendix 8. Correlation between capital intensity and sex ratio among population aged 0-4

VARIABLES	Sex ratio
	(1)
ln(K/L)	0.0001
	(0.0002)
Year fixed effects	Yes
Commune fixed effects	Yes
R-squared	0.052
Observations	23,289
Number of communes	7,763

Note: District-clustered robust standard errors in parentheses (*** p<0.01, ** p<0.05, * p<0.1).

Appendix 9. Correlation between capital intensity and educational attainment among population aged 23-55

VARIABLES	Ratio of population completed junior high school (9-year) as highest the degree			Ratio of population completed high school (12-year) as highest the degree			Ratio of population having college degrees (4-5 years)		
	Females (F)	Males (M)	F/M	Females (F)	Males (M)	F/M	Females (F)	Males (M)	F/M
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
ln(K/L)	0.0005***	0.0005***	0.0006	0.0006***	0.0004***	0.0029***	−0.0001***	−0.0001***	−0.0043***
	(0.0001)	(0.0001)	(0.0005)	(0.0001)	(0.0001)	(0.0004)	(0.0000)	(0.0000)	(0.0008)
Year fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Commune fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
R-squared	0.727	0.740	0.262	0.606	0.614	0.265	0.626	0.655	0.091
Number of communes	7,763	7,763	7,763	7,763	7,763	7,763	7,763	7,763	7,763
Observations	23,289	23,289	23,277	23,289	23,289	23,269	23,289	23,289	22,927

Note: District-clustered robust standard errors in parentheses (*** p<0.01, ** p<0.05, * p<0.1).

Appendix 10. Correlation between capital intensity and educational attainment among population aged 23-55 who stayed in the commune for more than 5 years

VARIABLES	Ratio of population completed junior high school (9-year) as highest the degree			Ratio of population completed high school (12-year) as highest the degree			Ratio of population having college degrees (4-5 years)		
	Females (F)	Males (M)	F/M	Females (F)	Males (M)	F/M	Females (F)	Males (M)	F/M
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
ln(K/L)	0.0005***	0.0005***	−0.0002	0.0006***	0.0004***	0.0012**	−0.0001***	−0.0000**	−0.0043***
	(0.0001)	(0.0001)	(0.0006)	(0.0001)	(0.0001)	(0.0005)	(0.0000)	(0.0000)	(0.0008)
Year fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Commune fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
R-squared	0.689	0.699	0.206	0.557	0.523	0.238	0.545	0.568	0.091
Number of communes	7,763	7,763	7,763	7,763	7,763	7,763	7,763	7,763	7,763
Observations	23,289	23,289	23,192	23,289	23,289	23,125	23,289	23,289	22,927

Note: District-clustered robust standard errors in parentheses (*** p<0.01, ** p<0.05, * p<0.1).

Appendix 11. Correlation between capital intensity and incoming migrants aged 23-55

VARIABLES	Females (F)	Males (M)	F/M
	(1)	(2)	(3)
ln(K/L)	0.0000**	0.0000	0.0184***
	(0.0000)	(0.0000)	(0.0039)
Year fixed effects	Yes	Yes	Yes
Commune fixed effects	Yes	Yes	Yes
R-squared	0.061	0.011	0.177
Number of communes	7,763	7,763	7,760
Observations	23,289	23,289	20,555

Note: District-clustered robust standard errors in parentheses (*** p<0.01, ** p<0.05, * p<0.1).

Appendix 12. Correlation between capital intensity and educational attainment among population aged 23-55 who moved in the commune for less than 5 years

VARIABLES	Ratio of population completed junior high school (9-year) as highest the degree			Ratio of population completed high school (12-year) as highest the degree			Ratio of population having college degrees (4-5 years)		
	Females (F)	Males (M)	F/M	Females (F)	Males (M)	F/M	Females (F)	Males (M)	F/M
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
ln(K/L)	0.0000***	0.0000**	0.0070*	0.0000***	0.0000***	−0.0027	−0.0000***	−0.0000***	0.0028
	(0.0000)	(0.0000)	(0.0039)	(0.0000)	(0.0000)	(0.0034)	(0.0000)	(0.0000)	(0.0032)
Year fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Commune fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
R-squared	0.186	0.029	0.188	0.026	0.040	0.073	0.180	0.025	0.181
Number of communes	7,763	7,763	7,478	7,763	7,763	7,630	7,763	7,763	6,864
Observations	23,289	23,289	15,556	23,289	23,289	15,267	23,289	23,289	12,975

Note: District-clustered robust standard errors in parentheses (*** p<0.01, ** p<0.05, * p<0.1).

Appendix 13. Correlation between cyclone damage index and number of firms (by ownership types) located in the commune

VARIABLES	All	POE	FOE	SOE
	(1)	(2)	(3)	(4)
Cyclone damage	−0.0031***	−0.0030***	0.0000	−0.0009***
	(0.0003)	(0.0004)	(0.0001)	(0.0002)
Year fixed effects	Yes	Yes	Yes	Yes
Commune fixed effects	Yes	Yes	Yes	Yes
R-squared	0.397	0.397	0.397	0.397
Observations	23,289	23,289	23,289	23,289
Number of commune	7,763	7,763	7,763	7,763

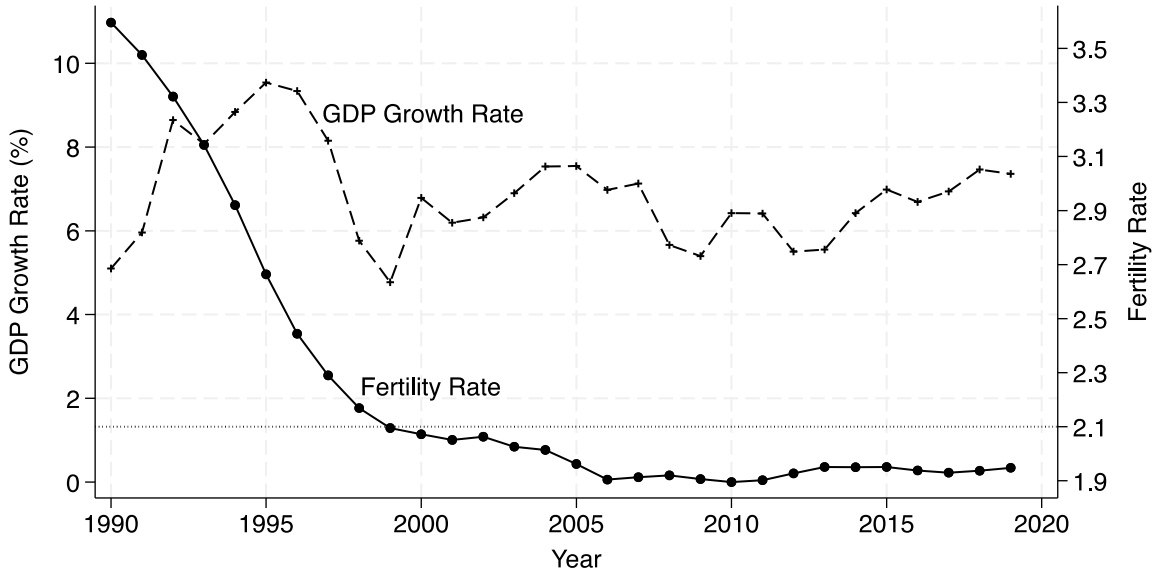
Note: District-clustered robust standard errors in parentheses (*** p<0.01, ** p<0.05, * p<0.1). SOE: state-owned enterprises; POE: private affiliated enterprises; FOE: foreign affiliated enterprises.

Appendix 14. Capital intensity and number of employees from formal sectors in the commune

VARIABLES	Ln(F)	Ln(M)	Ln(F/M)
	(1)	(2)	(3)
Ln(K/L)	0.2109***	0.2553***	−0.0444***
	(0.0214)	(0.0182)	(0.0095)
Year fixed effects	Yes	Yes	Yes
Commune fixed effects	Yes	Yes	Yes
F-statistics in the first stage	105	105	105
Observations	23,289	23,289	23,289
Number of commune	7,763	7,763	7,763

Note: District-clustered robust standard errors in parentheses (*** p<0.01, ** p<0.05, * p<0.1).

Appendix 15. GDP growth rate and fertility rate in Vietnam



Source: The World Bank (https://data.worldbank.org/indicator/NY.GDP.MKTP.KD.ZG?locations=VN and https://api.worldbank.org/v2/en/indicator/SP.DYN.TFRT.IN?downloadformat=excel).