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The Feminisation of Agriculture with Chinese Characteristics

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ABSTRACT *The objectives of this article are to assess whether or not the feminisation of agriculture is occurring in China, and if so, to measure its impact on productivity. To meet these objectives, we rely on three data sets that allow us to explore who works on China's farms and the effects of the labour allocation decisions of rural households on productivity. We find that since the late 1990s, the role of women has increased in both the supply of farm labour and in the duties that they take on in the management of farms. While this expansion is important, we further demonstrate that when women do a majority of farm work or manage the farm, their farms are equally efficient as farms managed by men.*

Increasing participation by women in farming has been documented in many countries (IFAD, 1999; Ganguly, 2003). This phenomenon raises the question: 'Does the feminisation of agriculture positively or negatively affect agricultural productivity?'

The concern is that women may face multiple limitations in their participation in agricultural markets, thus limiting overall agricultural production. For example, when women manage agricultural production, they often have less access to all types of inputs – physical inputs such as fertilisers or improved seeds; high quality or irrigated land; human capital; or even social and political capital, including social networks (Peterman et al., 2010). As a result, production on plots controlled by women is often lower than on plots controlled by men, even sometimes within households (Udry, 1996). Profits are also lower (for example in Ghana – Goldstein and Udry, 2008). Differences in productivity can usually – although not always – be explained either by understanding the context or controlling for inputs (Quisumbing, 1996; Peterman et al., 2010). Needless to say, if the amount of farm work performed by women or the proportion of land controlled by women is increasing and women are less productive than men due to limited access to inputs, overall agricultural production may be in danger of stagnating or even declining, with potential consequences for within country food security (UNDP, 2003).

Beyond concerns about agricultural productivity (and the related issues of domestic food prices and food security), scholars are also concerned about the potential effects of agricultural

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feminisation on women's welfare. Women might be forced to work more hours and take on increased responsibilities in addition to traditional roles, which would reduce their welfare level. Furthermore, the feminisation of agricultural labour could have negative effects on women's income, especially as women have less access to resources, such as high quality land and credit (Katz, 2003).

For the same reasons discussed in the international literature, agricultural feminisation has been an important issue in discussions about China's recent agricultural modernisation. The absence of much empirical literature means that even basic facts are not clear; in fact, disagreement exists about whether or not agricultural feminisation is even occurring. On one hand, several published and unpublished studies of the role of gender in China's agriculture argue that agricultural feminisation began in the 1990s (Jacka, 1997; Rawski and Mead, 1998; Song and Zhang, 2004). More recently, Chang et al. (2011) and Mu and van de Walle (2011) both show evidence of greater female participation in farming during the 2000s. On the other hand, de Brauw et al. (2008) show that while women's farm labour participation was high, as measured as a share of total labour input into farming, during the 1990s there was not systematic movement of women into farming. In other words, the share of the total labour input into farming by women was nearly unchanged. Differences in timing and approaches in the various studies may help explain these discrepancies.

As elsewhere in the world, there also is a debate on the effect of agricultural feminisation in China – on women themselves, on their households and on the national food supply. One set of scholars have been concerned that when women are left to tend the fields and have poor access to off-farm employment, they earn less than men for their on-farm work and have lower welfare (Song and Jiggins, 2000). Alternatively, if overall production stagnates, there could be negative effects on food security. However, given the sustained increase in agricultural yields and total factor productivity during the 1990s and 2000s (Jin et al., 2002; Jin et al., 2009), it is difficult to believe that agricultural feminisation – if it is happening – could be having a negative effect on productivity in China.

The goals of this article are to contribute to the ongoing discussion on the changing status of women in China's rural labour markets, to understand how the feminisation of agriculture may have changed, particularly over the 2000s, and to measure whether feminisation is influencing agricultural productivity. To be specific, the article has two primary objectives. First, we seek to answer the question: Is agriculture in China being feminised? Second, we attempt to quantify correlates with feminisation – variables that may be associated with causes and effect, if any, that agricultural feminisation has on way farming is carried out, the wealth of female-headed households and the productivity of women-managed farms.

Before we can study these questions, we must define agricultural feminisation. We define agricultural feminisation in two ways. First, we assume the feminisation of agricultural labour occurs when the proportion of farm work done by women increases on a specific farm. Second, we assume the feminisation of farm management occurs when women increasingly make decisions about farm production, such as what crops to produce, the amount of inputs to use, and how much produce to sell. The latter concept is more difficult to measure, so here we define managerial feminisation as occurring when the household is female headed.

The objectives of our article are tempered by several data limitations. First, the findings in the article are either descriptive or should be interpreted as conditional correlations, rather than as causal. We lack instruments to identify female headship, and there may be unobservable factors that are associated with female farm management that might also affect grain yields. Second, we focus on documenting agricultural feminisation and its relationship with agricultural productivity, and do not attempt to address other potential effects of agricultural feminisation. For example, we do not attempt to analyse changes in relative wages between men and women, because we do not have the necessary data. Nor do we claim that our analysis is representative of all parts of China. Finally, while we analyse the relationship between household welfare and the

gender of the household head, our analysis is limited to one narrow measure of welfare, household assets.

In spite of these limitations, we draw on multiple datasets to show that agricultural labour has become increasingly feminised, both in terms of labour allocation and management. Controlling for key variables such as location and the nature of the farming resources, female headed households are equally efficient as male headed households in agricultural production. Moreover, after we control for location, we find that women appear to have equal access to inputs such as fertiliser and land. Finally, when households switch from male to female headed, we find their asset levels do not decrease.

Data

We use three data sources for this study. The first data set was collected by the authors in a randomly selected, nearly nationally representative sample of 60 villages in six provinces (Hebei, Liaoning, Shaanxi, Zhejiang, Hubei, and Sichuan) of rural China in two waves. The first wave was collected in November and December 2000 (henceforth, the China National Rural Survey or *CNRS-2000*), and the second wave was collected in early 2009 to cover 2008 (*CNRS-2008*). To ensure broad coverage within each province in 2000, one county was randomly selected from within each income quintile for the province. Two villages were then randomly selected within each county.

The *CNRS-2000* includes a total of 1199 households in 60 villages. The survey gathered information on household demographics, labour allocation, agricultural production, and non-farm activities. Several parts of the survey were designed to learn about the household's participation in labour markets over time. Most pertinent to this study, the *CNRS-2000* collected detailed information about each household member's on-farm work in the previous 12 months. It asked whether or not each household member worked on the farm, then if so the number of weeks, days per week, and hours per typical day they worked on the farm during busy and slack seasons, respectively. By summing the number of hours they worked overall in the busy and slack seasons, we estimate the number of hours each household member worked on the farm. The agricultural production modules asked about plot level area and production by crop, but only about household level input use.

To collect the *CNRS-2008*, enumerators returned to 58 of the original 60 villages and attempted to interview all of the households included in the *CNRS-2000*.¹ When households were no longer living in the village, they were tracked by phone to their current location. We use information on the 1071 households that were still present in the villages for our analysis; a total of 1159 households were surveyed. The same modules were used to collect information about time spent working on the farm and agricultural production. Of the 1071 households included in the survey, 16.4 per cent were female headed in 2008.

Second, we use the China Health and Nutrition Survey (*CHNS*) to track agricultural labour trends over a longer period of time. The *CHNS* was collected by researchers at the University of North Carolina at Chapel Hill and their Chinese collaborators in 1991, 1993, 1997, 2000, 2004, 2006 and 2009.² The data we use were collected in over 2000 households in rural areas of seven provinces: Guangxi, Guizhou, Henan, Hubei, Hunan, Jiangsu, and Shandong.³ Although the data include a household level panel, we work with the repeated cross-section data to avoid cohort and attrition biases, as the panel ages over time. Regarding effort expended in the agricultural sector, the *CHNS* asked how many hours per day, days per week, and months per year each individual worked in the garden (vegetable plots near the house), on the farm, on livestock activities, and in fishing. The advantage of using the *CHNS* is that it asked exactly the same questions about farm labour in each survey round in the same set of villages, so the data illustrate how farm labour allocations have changed over time in a consistent manner.

Although the *CNRS-2000* and *CNRS-2008* both asked about what was grown on major plots held by each household, it did not ask about plot-specific inputs. Therefore we also use a third

source of data, the Fujian Rice Survey (FRS), to control for plot level inputs. In 2010, the authors undertook a rice input and output production survey. This survey was conducted in 124 households in Shunchang and Youxi counties in Fujian. Although the survey is small and concentrated in the rice-producing region of one province, we believe the results from the efficiency analysis are still comparable to the CNRS because the FRS survey instrument asked almost the same set of questions of the respondents as the CNRS-2000 survey, with more detail on specific plots. Because some farmers planted two rice plots, the survey included a total of 168 rice plots.

Is Feminisation of Agriculture Occurring in China?

The tremendous push of labour into the off-farm market –which, as Rozelle et al. (1999) find, is composed mostly of men especially in the early years –is one of the motivating forces behind the rise of concerns about agricultural feminisation. By 2007, Cai et al. (2009) estimate that the migrant labour force included 136 million people. When such significant numbers of people are observed moving out of rural communities, a natural question arises: who is doing the work on the farm? Since the time endowment of a household/individual is fixed, if an individual is spending more (less) time off the farm, other things being equal, he or she will spend less (more) time on farm, holding the time allocated to work over leisure fixed.

Complicating the matter, increasing off-farm labour participation varies by both age cohort and gender. In studies using the CNRS-2000, de Brauw et al. (2002) and Zhang, de Brauw, and Rozelle (2004) find that in the 1990s and early 2000s, both men and women in the youngest cohort in the labour force (16 to 30 years old) were moving rapidly into the off-farm sector at comparable rates. At the same time, women between the ages of 36 and 50 tended to remain both in rural source communities and working on the farm, whereas men did not (Zhang et al., 2004). Therefore, these papers conclude that women who are somewhat older are taking over more farm work, rather than younger or significantly older generations.

An important trend that appears in the CHNS is that *total* hours spent per household on farming activities fell sharply between 1991 and 2009 (Table 1). Furthermore, we condition the averages on farm participation, which also drops. According to the CHNS, among households allocating labour to farming, the average total hours spent per household on the farm fell from more than 3500 hours in 1991 to just over 2000 hours in 2000 (Table 1, row 1). Between 2000 and

Table 1. Participation in farm work by men and women, China Health and Nutrition Survey, 1991–2006

	Year						
	1991	1993	1997	2000	2004	2006	2009
Average total reported hours of farm work, household, conditional on positive farm work	3528 (174.3)	2743 (133.1)	2356 (127.4)	1976 (145.6)	1756 (145.2)	1557 (120.3)	1399 (126.3)
Share of households reporting positive hours of farm work	89	87	81	75	70	65	65
Average hours of farm work done by women, conditional on farm work done by household	1943 (96.7)	1431 (69.2)	1192 (63.7)	1058 (76.4)	927 (75.7)	867 (63.5)	748 (63.7)
Average share of farm work done by women	0.53	0.55	0.53	0.55	0.57	0.60	0.59
Number of observations	2290	2236	2393	2389	2338	2355	2385

Notes: Standard deviations in parentheses. Year refers to the year survey was completed. Farm work is defined to include time spent ‘gardening’ and ‘cropping,’ and omits time spent tending livestock or fishing. *Source:* CHNS, 1991–2009.

2009, the hours spent farming continued to fall, to about 1,400 hours in 2009, or a further 30 per cent decline.⁴ Meanwhile, the proportion of households reporting spending any time on the farm declined from almost 89 per cent of households in 1991 to 75 per cent in 2000 and 65 per cent in 2009 (row 2). These declines which occurred as off-farm employment increased rapidly – are consistent with the findings of de Brauw et al. (2004) and Jin et al. (2002), who report the hours spent on the farm fell during the 1980s and 1990s as reforms allowed rural households increasing access to off-farm work.

Evidence of Feminisation

To learn whether the feminisation of agricultural labour is occurring as less labour is input into farming, we measure of labour feminisation in two ways. First, we aggregate the total number of annual hours each household reports working on the farm, and then do the same for women. Second, we measure the proportion of households who report all of the household farm labour being completed either by men or women.

Among CHNS households, we observe little change in the share of hours spent on the farm by women between 1991 and 1997 (Table 1, row 3). The average number of hours worked by women surveyed in the CHNS fell at a slightly faster rate than the number of hours worked per household (row 3). In 1991 women worked an average of 1943 hours on the farm, falling to 1192 hours in 1997. Since the total hours fell more for women between 1991 and 1997 (39 per cent) than for the farm household in general (33 per cent), there is no overall trend of women taking over more work on the farm.

We next measure the proportion of households in which either women or men do *all the farm work*. During the early 1990s (1991 to 1997), the percentage of households in which women did all the farm work rose from 14 to 16 per cent, or faster than the percentage of households in which men did all of the farm work, which remained constant at 11 per cent (Figure 1). However, we cannot reject the hypothesis that the two percentage point rise in the share of households in which women do all the farm work is different from zero. Both measures of feminisation are therefore in conflict with previous research expressing concerns about the rapid rate of agricultural feminisation in China during the 1990s (Jacka, 1997; Song and Jiggins, 2000).

After the 1997 survey round, trends change. The hours spent in agriculture among farming households continued to fall between 1997 and 2009 (Table 1, row 1). While the average number of hours spent by women on the farm also declined from 1192 hours per year in 1997 to 748 hours per year in 2009, the decline in total hours worked by the household was faster.

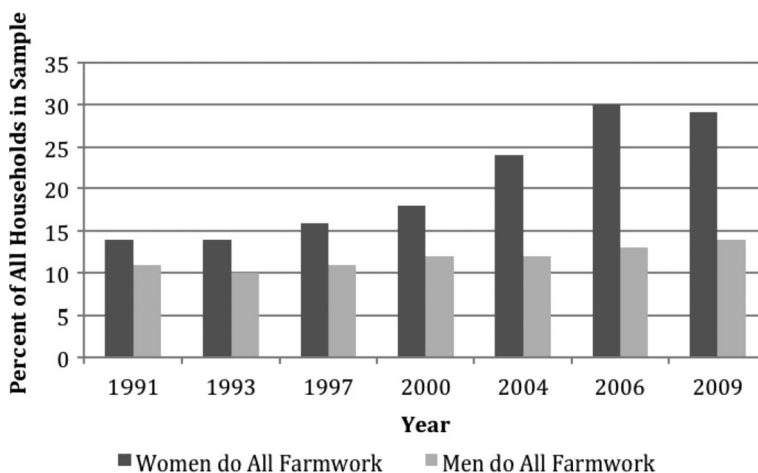


Figure 1. Per cent of households in which women or men do all of the farm work, 1991–2009, CHNS.

Consequently, the average share of farm work performed by women increased from 53 per cent in 1997 to 59 per cent in 2009.

The share of households in which solely women worked on the farm also rose sharply, from 16 per cent in 1997 to 30 per cent in 2009 (Figure 1). Combining the facts that the proportion of farm work done by women increased from 1997 to 2009, and that women did all the farm work more frequently in 2009 than 1997, we conclude the feminisation of agricultural labour has been occurring in China since the late 1990s.

The Feminisation of Farm Management: Correlates, Causes, and Effects

Given the feminisation of agricultural labour and the fact that women are more likely to do all the farm work in a significant proportion of households, it follows that much of the work of managing a farm has also become the responsibility of women in an increasing share of households. We next want to begin to understand the consequences of managerial feminisation. We define female-managed farms or female-headed households as households in which either the household named a female as the head, or the male head migrated and was away from the household for six months or more.⁵ It is important to note that this definition is clearly a proxy; households may divide responsibilities even when men are present with women managing the farm, or men may make management decisions about farming even while absent (Mu and van de Walle, 2011). Nonetheless, in the absence of a better measure of female farm management we use this definition.

In this section, we have three specific objectives. First, we examine whether female and male headed households have similar access to inputs. Second, we examine the relative efficiency of female-headed and male-headed households in farming. Third, we examine household welfare levels when women manage farms rather than men.

Access to Means of Production: Do Women Have Access to Inputs?

According to the CNRS, women and men have equal access to land regardless of whether farming activities of households are headed by men or women (Table 2). In fact, access to land is one of the defining characteristics of China's farming sector.⁶ In 2000, literally 100 per cent of all male and female-headed households had access to land (row 1). In 2008, the rates were almost the same –97.3 per cent of male-headed households and 97.1 per cent of female-headed households. In both years of the survey, male-headed and female-headed households also had access to equal numbers of plots (row 2).

At least in terms of point estimates, gaps in terms of farm size and allocations widened slightly between 2000 and 2008. In 2008, male-headed households held more land than female-headed households (Table 2, row 3). In 2000, male-headed households were allocated 4.22 *mu* on average, while female-headed-households were allocated only 3.81 *mu*⁷. However, this difference is not statistically significant. By 2008, the gap widened and the difference in means became statistically significant. Male-headed households reported being allocated 6.36 *mu*; female-headed households reported allocations of only 3.33 *mu*. Land holdings per capita and total land holdings (allocated land plus rented-in land) showed the same trends: differences between female and male headed households existed in 2000 and widened over time (rows 4 and 5).

By several measures, female headed households also own less farm equipment than male headed counterparts (Table 2, rows 6 to 8). Perhaps related to the fact that female headed households had less land, female-headed households owned less major farm implements than male headed households (row 6), and the value of farm equipment owned was also lower (row 7). A larger share of female-headed households also owned no farm equipment (row 8). Notably, the gap between female and male headed households widened somewhat between 2000 and 2008. During that period, the proportion of both female and male headed households with no farm equipment also increased, suggesting that some households may be moving out of farming.

Table 2. Land holdings by male, female-headed households, CNRS 2000 and 2008

	2000			2008		
	Male-headed	Female-headed	p-value	Male-headed	Female-headed	p-value
Land						
Household has access to land	99%	100%	–	97.3%	97.1%	0.893
Number of plots held	6.34 (0.36)	6.1 (0.68)	0.729	5.13 (0.35)	5.57 (0.73)	0.416
Total amount of allocated land	4.22 (0.19)	3.81 (0.39)	0.269	6.36 (0.72)	3.33 (0.24)	0.0001
Land holdings per capita	2.56 (0.24)	1.54 (0.18)	0.0002	2.20 (0.23)	1.27 (0.11)	0.0002
Total land holdings	8.57 (0.71)	5.19 (0.63)	0.0001	7.91 (0.65)	4.89 (0.40)	0.0001
Capital						
Number of major farm Implements owned	1.184 (0.068)	0.809 (0.117)	0.001	1.118 (0.084)	0.608 (0.077)	<0.0001
Value of farm implements Owned (nominal)	1162.5 (101.1)	557.1 (108.3)	0.0001	1281.1 (218.7)	330.8 (79.5)	<0.0001
Percent of HHs, No farm Implements	34%	47%	0.006	41%	58%	0.0003
Fertiliser						
Percentage purchasing Fertiliser	92%	86%	0.078	86%	67%	0.330
Value of fertiliser Purchased/mu	74 (4.0)	71 (4.9)	0.553	85 (6.6)	64 (10.6)	0.037

Notes: ‘Total’ landholdings include privately held land, land allocated by the village, land contracted from the village, and any land rented in by the household.

Just as there are differences in access to land and farm equipment, by 2008 female-headed households also appear to use less chemical fertiliser than male-headed households (Table 3). In 2000, female-headed households purchased fertiliser at similar rates and used similar volumes of chemical fertiliser as male-headed households; we cannot reject the null hypothesis that amounts used are equal (columns 1 to 3, rows 9 and 10). In 2008, statistically significant gaps appeared (column 4 to 6). Female headed households were both less likely to purchase fertiliser (row 9) and used less fertiliser in value terms (row 10).⁸

In sum, according to the descriptive statistics, female headed households appear to have (slightly) less access to land, capital, and fertiliser. However, it is not yet clear whether these differences affect farm productivity. We next explore whether managerial feminisation is associated with lower farm earnings. After discussing farm productivity, we return to discussing apparent differences in access to land and other inputs.

Effect of Managerial Feminisation: Are Women as Productive?

From the international literature on women in agriculture, there is ample evidence that female-headed households and women-cultivated plots have produced lower yields and revenues (World Bank, 2001). Beyond input access, women might be less efficient producers for a variety of reasons. Women also must do other work, such as child rearing and housework burdens, not typically done by men (Peterman et al., 2010). If we find that the feminisation of farm management is associated with lower output in China, then some of the gains women have received in the off-farm sector may be offset by lower earnings in the farm sector.

We therefore initially want to know whether or not female headed households are as productive on the farm as male headed households, before controlling for inputs. To answer this question, we initially set out to test whether yields of similar crops planted by women and men are different. To control for differential cropping patterns, we first identify all the plots planted in

Table 3. Relationship between female headship and logarithm of yields on plots growing primary grain crop, CNRS, 2000 and 2008

Variable	2000		2008	
	(1)	(2)	(3)	(4)
Constant	6.353 (0.003)	6.333 (0.027)	6.586 (0.004)	6.557 (0.037)
Female head	0.034 (0.033)	0.035 (0.033)	0.017 (0.037)	0.017 (0.032)
Plot characteristics				
Single crop		-0.060 (0.059)		0.037 (0.049)
Hilly plot		-0.026 (0.022)		-0.033 (0.038)
Terraced plot		-0.134 (0.047)		-0.011 (0.061)
Reported a shock on plot		-0.167 (0.030)		-0.157 (0.035)
Irrigated plot		0.135 (0.062)		0.034 (0.030)
Reported high quality plot		0.106 (0.017)		0.068 (0.025)
Village fixed effects?	yes	yes	yes	yes
N	2819	2819	2002	2002

Notes: Standard errors clustered at the village level in parentheses.

Source: CNRS 2000 and 2008.

the most frequently planted grain crop in each village. We then explore whether grain yields are systematically lower among female-headed households than male-headed households. Therefore we measure whether women are as productive as men, conditional on planting the most frequently planted grain in the village. We do so both within each cross-section and by constructing a panel between the two survey rounds.

One question is whether or not these plots are representative of the farming activity of the villages in the CNRS. In 2000, 91 per cent of all farming households grew the primary (or most commonly produced) grain in the village, but only 74 per cent did so in 2008, indicating that conditions changed between the two surveys. Some of this change is at the village level; by 2008 several villages in the data set had specialised in growing specific crops. If we eliminate four villages from the sample with complete specialisation between 2000 and 2008, 77 per cent of farming households grow the primary grain in the village, which is slightly more comparable to the average from 2000.

To estimate yield determinants in the cross-section, for the 2000 and 2008 data we separately estimate a model of the form:

$$\ln(y_{ihv}) = \alpha_v + F_{hv}\gamma + \mathbf{P}_{ihv}\eta + \varepsilon_{ihv} \quad (1)$$

where y_{ihv} represents the yield for plot i farmed by household h in village v , which is regressed on the female-headed household dummy variable, F_{hv} , and a vector of plot level characteristics \mathbf{P}_{ihv} .⁹ Our null hypothesis is that the coefficient on the female managed farm variable, $\gamma = 0$, or that yields are no different on farms run by women than on farms run by men. We initially estimate the regression suggested by Equation (1) separately for 2000 and 2008, whether or not we hold plot characteristics constant.

When we estimate whether the logarithm of primary grain yields are different among male and female-headed households, without holding plot level covariates constant (Table 3; columns 1

and 3), we find results that are generally at odds with the results from other parts of the world (World Bank, 2001; Peterman et al., 2010). In both years, we find that we cannot reject the null hypothesis that $\gamma=0$. Moreover, we estimate positive coefficients on the female-headed household indicator variable. This finding either implies that female-headed households have the same yields, on average, as male-headed households have in both survey rounds, or that they have higher yields. These findings do not change when we control for plot level characteristics (Table 3; columns 2 and 4). According to is empirical exercise, it appears that female-headed households produce grains with yields that are no different than those of male-headed households.

Robustness Checks

Yields and shifting from male to female headed households. One of the ways that the process of agricultural feminisation occurs is when women take over primary management responsibilities of the farm. Between 2000 and 2008, some households switched from being male headed households to female headed households. We therefore assume that managerial feminisation occurred for those households. As we have data on these households before and after the shift from male headed to female headed, we can study the impact of feminisation on this group of households.

The core question, then, is whether or not productivity in primary grains declined for households that shifted from male headed to female headed. The regressions in Table 3 above did not detect any change in productivity, potentially because we did not pool the data across the two rounds to study how productivity changes.

To answer this question, we pool our data sets from the two years and estimate the following regression:

$$\ln(y_{iht}) = \alpha_h + \beta_1 D_t + \beta_2 F_{hvt} + \beta_3 D_t \cdot F_{hvt} + \mathbf{P}_{iht} + \varepsilon_{iht} \quad (2)$$

where t now indexes time. In Equation (2) we include household fixed effects (α_h) to control for fixed unobservables at the household level. To control for differences over time in Equation (3), we now include individual explanatory variables for the survey round (D_t), an indicator for female-headed households indexed over time (F_{hvt}), and the interaction between the two ($D_t \cdot F_{hvt}$). The coefficient β_2 represents the difference in yield between female-headed and male-headed households in the CNRS-2000, and β_3 represents the change in the difference in yields between female-headed and male-headed households between the CNRS-2000 and the CNRS-2008. In this regression, the average difference in yields between female- and male-headed households in the CNRS-2008 is then the sum of the coefficients on female head, the interaction term, $\beta_2 + \beta_3$. The null hypothesis we want to test is whether ornot there is a difference in yields between female- and male-headed households in 2008, or that $\beta_2 + \beta_3 = 0$. If we reject the null hypothesis, we will be able to conclude that female-headed households have different (or lower) yields in 2008 than male-headed households.

We estimate Equation (2) and find that there is still a positive coefficient on the female-headed household indicator variable (Table 4, columns 1 and 2). However, we find a negative coefficient on the interaction term, indicating that yields did not grow as quickly among female-headed households. The point estimate for the estimate of $\beta_2 + \beta_3$ implies that yields among female-headed households are 6.4 percent lower than among male-headed households in 2008, controlling for other plot characteristics (column 2). Despite the negative sum of the coefficients, we cannot reject the hypothesis that the coefficients add to zero. Therefore, our initial interpretation is that women-managed farms in 2008 are still equally efficient as farms managed by men.

Table 4. Relationship Between female headship and logarithm of yields on plots growing primary grain crop, controlling for household fixed effects in panel regression, CNRS, 2000 and 2008

Variable	All villages		Poor villages only	
	(1)	(2)	(3)	(4)
Round (2008 = 1)	0.297 (0.074)**	0.253 (0.058)**	0.345 (0.097)**	0.304 (0.076)**
Female head?	0.057 (0.090)	0.048 (0.083)	0.080 (0.118)	0.086 (0.108)
Round-female head interaction	-0.176 (0.115)	-0.112 (0.101)	-0.227 (0.141)	-0.168 (0.123)
Plot characteristics				
Single season		-0.043 (0.068)		-0.098 (0.100)
Hilly plot		0.017 (0.036)		-0.005 (0.044)
Terraced plot		-0.155 (0.095)		-0.241 (0.132)
Shock on plot?		-0.284 (0.056)**		-0.301 (0.063)**
Irrigated?		0.194 (0.067)**		0.212 (0.075)**
Reported high quality		0.076 (0.020)**		0.098 (0.026)**
Household fixed effects?	yes	yes	yes	yes
Combined female head effect, 2008	-0.119 (0.075)	-0.064 (0.071)	-0.146 (0.071)**	-0.082 (0.095)
N	4821	4821	3298	3298

Notes: Standard errors accounting for village level clustering in parentheses.

Source: CNRS 2000 and 2008.

The location of female headed households. Although we do not find any initial productivity differences between male and female-headed households, systematic differences in labour allocation could occur across space within the CNRS. It could be that in more developed villages, female management does not affect productivity, whereas access to inputs is worse for female headed households in less developed villages. By not differentiating richer and poorer villages, one might be concerned that in columns 1 and 2 of Table 4 we have estimated an average and we miss negative consequences of feminisation in less developed villages.

To test this hypothesis, we split the sample into ‘rich areas’ and ‘poor areas’ as follows. We define the richer areas in our sample as the households in Zhejiang Province and the richest county in each other province.¹⁰ Poor areas are then defined as all other counties in the sample. Then we re-estimate Equation (2) using poor areas both with and without plot characteristics (Table 4, columns 3 and 4) and find that the combination of estimates of β_2 and β_3 remains negative (8.7 per cent when controlling for plot characteristics). The difference is statistically significant when we do not include plot characteristics in the regression (column 3), but statistically insignificant once we do so (column 4). Even if households in in poor areas that have become female-headed between survey rounds have lower yields, on average, for primary grains, the difference appears to be generated by differences in plot characteristics. Although female headed households are as productive as male headed households, household welfare may be lower due to the apparent inequality in access to resources described earlier.

Efficiency in 2010. Because of changes between 2000 and 2008 in access to land and other inputs – such as farm equipment, custom services and fertiliser – between male and female headed

households, we next examine the relative efficiency of male and female-headed households using the Fujian Rice Survey, which allows us to control for plot level inputs.

To estimate the efficiency impacts of having a female head in 2010, we use a modified version of Equation (1), in which we include several plot level input measures (Table 5). We use rice yields alone (column 1) and the natural logarithm of rice yields (column 2) as the dependent variables. Controlling for inputs at the plot level, regression results again provide no evidence that women are any less efficient than men. The estimated coefficient on the female-headed household indicator is not significantly different from zero, regardless of the form of the yield variable (row 1).¹¹ Again, we find female-headed and male-headed households operating at equally technically efficient points on the rice production function.

Access to agricultural inputs. Given that female-headed and male-headed households appear to be equally efficient, we next seek to explain why we observe differences in access to inputs between male-headed and female-headed households. One potential source of heterogeneity might be that female-headed households are more common in poor areas and male-headed households are more common in rich areas. Lower land quality in poor areas could explain why

Table 5. OLS estimation of rice yields (and log of rice yields) in Fujian using 'female-headed household-based' measure of agricultural feminisation (Z_{hv}) in 2010

Variables	Yield (kg/mu)	Ln (Yield)
Female headed household?	29.879 (40.105)	0.060 (0.080)
Age of household head (years)	0.933 (0.787)	0.091 (0.074)
Education of household head (years)	0.282 (3.067)	-0.009 (0.018)
Labour inputs (hours/mu)	0.284 (0.189)	0.077 (0.033)**
NPK fertiliser (kg/mu)	0.242 (0.774)	0.005 (0.022)
Proportion of N in NPK (%)	0.533 (0.738)	-0.002 (0.002)
Proportion of K in NPK (%)	0.476 (0.714)	0.001 (0.002)
Pesticide cost (yuan/mu)	-0.082 (0.278)	-0.012 (0.010)
Machinery cost (yuan/mu)	0.103 (0.085)	0.006 (0.005)
Ratoon rice dummy	-74.904 (28.361)***	-0.191 (0.056)***
Middle season rice dummy	5.999 (40.168)	0.006 (0.082)
Quality of land (1 = good; 2 = bad)	32.422 (15.585)**	0.075 (0.031)**
Plot area (mu)	1.084 (8.749)	0.020 (0.026)
County dummy	1.936 (26.411)	-0.037 (0.049)
Constant	419.737 (79.634)***	5.621 (0.349)***
Observations	168	168
R-squared	0.314	0.358

Notes: Standard errors in parentheses. *, **, and *** represent statistically significant at 10 per cent, 5 per cent and 1 per cent respectively.

Source: Fujian Rice Survey.

female headed households systematically use less fertiliser. The observations that female headed households use less fertiliser than male headed households would not then be due to an access problem, but rather consistent with the rational use of resources: rational farmers would use fewer inputs on more fragile land.

Are there indeed more female headed households in poor areas? We find that in 2000, there were fewer female headed households in poor areas (8 per cent) than in richer areas (10 per cent). However, between 2000 and 2008 more households changed from male to female-headed in poor areas (8 percentage points) than in richer areas (5 percentage points), and as a result by 2008 there were more female-headed households in poor areas (17 per cent) than in richer counties (15 per cent). Clearly, if farmers in poor areas have relatively fragile land –which is almost certainly true –then their relatively low levels of fertiliser use can be explained. Therefore, it is important to control for the nature of the village economies when comparing differences between male and female headed households.

Inequalities in access to land. Another source of apparent inequality is in access to land. If female headed households are more prevalent in places where land is scarce, then the reason that the difference in land holdings per capita developing between male and female headed households widened is the spatial distribution of female headed households, rather than discrimination. If this hypothesis is correct, once we control for location the difference in land holdings between female and male headed households should disappear.¹² Therefore, we next control for location through province and village level indicators in a regression framework.

To test whether household location affects the difference between landholdings among male and female-headed households, we regress land holdings per capita on a dummy variable for female-headed households, sequentially adding the age of the household head, and either province or village indicator variables (Table 6). When we initially regress land per capita on a dummy variable for female-headed households with no location indicators (row 1), we observe the negative, statistically significant coefficient we expected from descriptive statistics, suggesting that female-headed households have access to less land. The sign and significance of the coefficient does not change when we add the household head's age to the regression (row 2). However, once we additionally control either for province or village level indicators (rows 3 and 4), the difference between landholdings in female and male headed households is no longer statistically significant. As a result, we can conclude that a large portion of the measured difference in average landholdings between female- and male-headed households is due to the location of female-headed households.

All the evidence taken together, we discover that female and male-headed households are actually equal in terms of access to inputs such as land and fertiliser when controlling for location. Moreover, female-headed households are equally efficient after accounting for differences in inputs.

Table 6. Regressions explaining variation in land per capita, CNRS, 2008

	(1)	(2)	(3)	(4)
Female-headed household	-0.769 (0.294)**	-0.782 (0.320)**	-0.271 (0.264)	-0.104 (0.257)
Age of head		-0.003 (0.009)	-0.005 (0.008)	0.010 (0.008)
Fixed effects?	no	no	Province	Village

Notes: Standard errors accounting for village level clustering in parentheses.

Source: CNRS 2008.

Female-headed Households and Asset Holdings

We have established that in general female-headed households are no less efficient than male-headed households in rural China. However, we may be concerned that female headed households have lower welfare levels: they cannot participate in more productive off-farm labour when they are working on the farm. Further, they may have to take care of children while farming. We therefore next compare the asset holdings of female and male headed households to ascertain whether welfare differences exist. If female headed households have lower asset levels, they might be considered less well off.¹³

We measure welfare using asset holdings in several different ways. First, we count the number of common consumer durables that households owned out of six in both 2000 and 2008.¹⁴ In 2000, we cannot reject the hypothesis at the 5 per cent level that female and male headed households own the same number of common consumer durables on average (Table 7, row 1). We also find no difference between the share of female and male headed households owning none of the six items, a measure of asset poverty (24.5% versus 20.0%). Finally, we find virtually no difference in the self-reported value of all consumer durables in 2000 between female-headed households (2933 *yuan*) and male-headed households (2981 *yuan* – row 2).

The number and value of asset holdings by households in the CNRS increased for both female and male headed households between 2000 and 2008. However, by 2008 the number and value of consumer durable holdings among female headed households fell behind male-headed households (Table 7, columns 3 and 4). In terms of all three measures, the status of female headed households improved, but not as much as among male headed households (rows 1–3). Furthermore, all three differences are statistically significant at the 5 per cent level. As such, in terms of consumer durables, the relative position of female-headed households fell between 2000 and 2008.

The deteriorating position of women, however, does not appear when looking at the most valuable asset holding of households in rural China, housing (Table 7, row 4). In 2000, the value of housing in male-headed and female-headed households was statistically indistinguishable. In fact, the point estimate of the reported value of the household's housing assets was higher for female-headed households (29,998 *yuan*) than for male-headed households (26,176 *yuan*). Although the ranking of the point estimates reversed in 2008 (the value of the housing assets for male-headed households was 86,560 *yuan* and the value for the female-headed households was 73,340 *yuan*), the annual growth rates of the value of housing assets of both male-headed and female-headed households was greater than 12 per cent, and the two values were not statistically different (columns 3 and 4, row 1).

Because of the dominance of the housing asset in the total asset holdings of both male-headed and female-headed households, when looking at total asset holdings (housing + consumer

Table 7. Consumer durable holdings, reported value of house, house plus durables, by gender of the household head, CNRS 2000 and 2008

	2000			2008		
	Male-headed	Female-headed	p-value	Male-headed	Female-headed	p-value
Number of common durables owned	1.91 (0.10)	1.61 (0.16)	0.0879	2.69 (0.11)	2.18 (0.14)	0.001
No common durables owned	20.0%	24.5%	0.43	12.0%	22.2%	0.000
Total value of durables owned (nominal)	2981 (363)	2933 (981)	0.963	7045 (1440)	3593 (526)	0.045
Reported value of house	26176 (2935)	29998 (7073)	0.465	86560 (24060)	73340 (15040)	0.512
Value of house + durables	29109 (3211)	32979 (7415)	0.485	93610 (24540)	76930 (15140)	0.423

durables), male-headed households and female-headed households are remarkably close in both 2000 and 2008 (Table 7, row 5). The point estimates of the total asset holdings of male-headed and female-headed households in the CNRS dataset in both 2000 and 2008 are not statistically different. Therefore, when considering total household assets, female headed households are just as well off as male headed households.

Summary, Policy Implication, and a Cautionary Alternative Explanation

In this study, we have shown that agricultural feminisation is indeed occurring in rural China. Conditional on the survey household location, when a woman manages the farm, our data demonstrate that they have approximately equal access to land, inputs and other resources, and they cultivate the land of the farm at least as efficiently as men. In addition, in China, at least during the 2000s, female-headed households are as well off as men, at least in terms of aggregate asset holdings.

One possible explanation for these findings relates to China's rural market environment. Markets are so competitive, efficient, and deep that they provide women with the services, inputs, markets for selling their produce and information that they need to efficiently operate and succeed in agriculture (Huang et al., 2004). Moreover, in human capital measures female household heads are approaching those of male household heads, which may allow them to take equal advantage of opportunities that China's agricultural markets offer.¹⁵

If these conjectures are correct, the policy implication for China would be to continue to do the things that have allowed China's markets to flourish. Government officials have not interfered too much in China's farming sector over the past 10 to 20 years. They have, however, invested heavily into the infrastructure that markets need to operate well: roads, communications and accessible wholesale marketing facilities, open to all and lightly taxed. In this environment, literally thousands of traders seek out agricultural producers who are willing to sell their goods – no matter if they are rich or poor; young or old; or male or female. Too many traders exist for any one trader to have enough market power to discriminate. Equal human capital investments for men and women have almost certainly played a supplemental role.

Finally, there may be lessons for the rest of the world on what policies and institutions help make women productive when they work in and manage production in the agricultural sector. Policies that ensure equal access to land, regulations that dictate open access to credit, and economic development strategies that encourage competitive and efficient markets have all contributed to an environment in which women farmers can and appear to succeed. However, China can do more by fostering initiatives to promote agricultural extension agents that are women. Although less than 30 per cent of extension agents in China are women overall, nearly 40 per cent of young ones are. When women have access to inputs and information and new technologies, there is no reason that they cannot produce at levels equally efficient to men.

Our results also point to the need for additional research. Although we can conclude that the feminisation of agricultural labour and farm management is not affecting agricultural productivity, it may affect women's welfare in other ways. These effects may also differ by region. Further research could focus on untangling the causes of the pattern of agricultural feminisation in China after the late 1990s. For example, it would be interesting to know if changes in the pace of industrialisation and the rise in demand for off-farm labour in the 1980s, 1990s and 2000s led to China's agricultural feminisation that we describe. This question is just one of a number of other lines of inquiry suggested by our findings.

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Notes

1. Unfortunately, two of the 60 original villages were in the Sichuan earthquake zone and were damaged so heavily that a year after the earthquake most households had not returned to their normal lives in the village. Therefore 40 households from these two villages were omitted from the 2008 survey.
2. We omit the 1989 CHNS because questions about agricultural labour were constructed differently in that round.
3. The CHNS is conducted in both rural and urban areas. In the subsample we study, we include data from villages in the counties considered rural as well as suburban areas of counties considered urban. Whereas a large majority of households in suburban villages farmed in 1991, very few did by 2009. As a result, we present average hours of farmwork conditional on doing any farm work. Because the CHNS also covers a large cross-section of China's provinces, it is somewhat representative of farm conditions more generally in China, as is the CNRS.
4. This finding is consistent with evidence from the CNRS-2000 and CNRS-2008. In the CNRS-2008, households reported that the hours spent on farm fell by more than 50 per cent relative to the CNRS-2000 average.
5. In most cases, the male was gone for either 11 or 12 months when gone for at least six months. We unfortunately cannot observe either households in which females made all or most of the decisions about farm management, so we use this definition to isolate the group of households in which farm decisions were most likely being made by females.
6. In China, all land is officially owned by the collective. By definition, all members of an administrative village with a residency permit (or *hukou*) in the village are members of the collective. The collective's interests are represented by a village leadership committee that is part elected and part appointed. Households are allocated land with 30-year use rights from the village leadership committee.
7. 15 mu are approximately equal to 1 hectare.
8. Female-headed households might also have less access to credit. Although we did not ask about credit in 2008, in 2000 we found no difference in credit access.
9. Plot level characteristics include whether or not the grain was single cropped, topography, whether or not a shock occurred on the plot, irrigation status, and farmer-reported quality.
10. De Brauw and Rozelle (2008) use the same split of poor and non-poor villages in studying the relationship between migration and household investment using the CNRS-2000.
11. In the online appendix, we show that if we use the share of hours worked on the farm by women as the measure of feminisation, we find similar results (Online Appendix Table A.2).
12. Female headed households may also be less likely to contract land in from the village and more likely to rent land out. We explore these hypotheses in the online appendix.
13. The use of alternative welfare measures might lead to different conclusions; unfortunately, assets are the only welfare measure available in the combined CNRS data set.
14. The six common consumer durable assets we consider are audio systems, refrigerators, washing machines, gas stoves, motorcycles and bicycles. Each demonstrated a great deal of variation in ownership in 2000, making them a reasonable combined welfare indicator.
15. See Appendix Table A.3 in the online appendix for evidence on human capital levels.

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