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Rural non-farm diversification, agricultural feminisation and women's autonomy in the farm: evidence from India

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This study contributes to the literature on the interlinkage between household non-farm diversification (HND), agricultural feminisation and female autonomy in farming. The study uses unit-level data from the Indian Human Development Survey for the years 2004 - 2005 and 2011 - 2012. The paper employs instrumental variable regression methods to study such interlinkages. The results show HND to be a significant factor contributing to the feminisation of agriculture. The study finds some evidence that the phenomenon is distress driven. Further, greater participation of women in agriculture, as well as women's access to land rights, significantly contributes to female autonomy in farm decision-making. The results are robust to the use of alternative indicators of agricultural feminisation.

Key words: agriculture, empowerment, female, instrumental variable, non-farm, rural.

1. Introduction

Non-farm employment has become a ubiquitous element of the rural economy. Rural livelihoods are increasingly diversifying into non-farm activities. Such diversification transpires because of returns to assets which vary across time or individuals; to exploit economies of scope; and/or as a response to market failures etc. (Barrett *et al.* 2001). Although the literature exploring the drivers of rising livelihood diversification is large, relatively lesser attention has been devoted to the influence of livelihood diversification on the structure of the rural economy (Davis *et al.* 2009). One such aspect, which is the subject of the current study, is the influence of household livelihood diversification on labour allocation and decision-making on the farm.

Despite the rising prevalence of non-farm activities among rural households, agriculture still has an important role to play in the development of the rural economy. Recent literature in this regard envisages a synergistic relationship between the farm and the non-farm sector for overall rural development (Davis *et al.* 2010). A concomitant issue that deserves attention

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is the gendered implications of the relation between the farm and the non-farm economy. The extant literature finds that the impact of household non-farm income on labour force participation of its members differs by gender (Mu and van de Walle 2011; Mendola and Carletto 2012). Such gender-specific heterogeneities in the impact of non-farm participation on labour allocation of household members are especially interesting given its implications for 'equity and efficiency' (Quisumbing *et al*. 2014).

The study assumes greater significance in the context of the discourse on agrarian distress. Declining returns from farming together with falling state support to the agricultural sector couple with other factors have led to an influx of people (generally men) to the non-farm sector (Deere 2005; Chand and Srivastava 2014). This phenomenon, together with high poverty rates in rural areas, has resulted in the movement of women into the farm sector for the survival of the household and to ensure basic food security (Deere 2005; Srivastava 2011; Rao 2012). Such a trend of rising female participation in farming, dubbed as the 'feminisation of agriculture', has consequences for the autonomy, empowerment and well-being of women left behind in agriculture[1] (Paris *et al*. 2005; Pattnaik *et al*. 2018). Besides, such a trend can have implications for farm productivity given women's unequal access to vital agricultural inputs (Food and Agriculture Organization 2011; Quisumbing *et al*. 2014). Finally, the discourse on the feminisation of agriculture further underscores the crucial role of women's access to agricultural assets such as land for their empowerment and overall agricultural productivity.

Although there have been a few studies which explore the impact of non-farm participation on labour use and decision-making in farming, they are primarily concerned with the impact of migration and remittances (Binzel and Assaad 2011; Mu and van de Walle 2011; Mendola and Carletto 2012; Tumbe 2015). However, given the pervasiveness of local non-farm activities among rural households, its impact on labour allocation in farming deserves equal attention. This is especially so in the context of India where both urban manufacturing growth and rural - urban migration have been sluggish and the rural non-farm sector has been playing a much more important role in employment generation (Binswanger-Mkhize 2013). Further, the study explores the crucial role of agricultural feminisation and women's land rights in influencing their autonomy in farming. To the best of our knowledge, this is one of the first studies to offer an empirically rigorous assessment of this relationship, especially in the context of India.

Specifically, the study attempts to answer the following research questions:

[1] Although the discourse on feminisation of agriculture has been used to highlight the rising participation of women in own farm as well as the agricultural wage labour market, in the present study we restrict ourselves to the later, that is, female participation in own farm work. The phenomenon of feminisation of agricultural wage work has been taken up in Garikipati (2009) and da Corta and Venkateshwarlu (1999), among others.

1. Does household diversification into non-farm activities lead to the feminisation of agriculture?
2. Does increasing participation in non-farm work and the feminisation in agriculture have any impact on female autonomy and decision-making in farm activities?
3. Does women's access to land rights have any bearing on their decision-making capacity in farming operations?

The paper is divided into six sections. Section 2 provides a conceptual framework for the study. Section 3 presents the data and the methodology, and Section 4 discusses the results. Section 5 provides some robustness checks. Section 6 concludes the paper and presents some policy suggestions.

2. Conceptual framework

Household diversification into non-farm activities can influence labour allocation and decision-making in farming through the following channels:

Firstly, non-farm participation can be a source of additional income to the household thereby potentially raising the reservation wages of its members and lowering labour force participation as well as engagement in farm work. Such a decline would be especially pronounced for females given social norms against their labour market participation in many regions in India. On the other hand, if non-farm diversification is due to a desire to cope with uncertain farm incomes, additional non-farm income may not increase total household income and will not have any effect on farm and overall work participation of its members.

Secondly, participation in non-farm activities also entails household labour re-allocation to non-farm activities which can have implications for farm labour. Such household engagement in non-farm work can lead to specialisation of its members with males spending relatively more time in non-farm activities and females increasing their involvement in farming. Such gender-specific response to non-farm participation is especially convenient for households given social norms against the participation of females in work outside the farm (Entwisle *et al.* 1995; Zuo 2004; Rao 2012).

The above discussion shows that theory, as well as logical reasoning, fails to provide us with unambiguous answers on the impact on non-farm diversification on household's labour allocation in farming. As such, we rely on empirical evidence to ascertain the effect of non-farm participation on household's labour allocation in farming.

2.1 Does the increasing participation of women in farming increase their say in farm-related decision-making?

In this regard, studies by Twyman *et al.* (2015) and Anderson *et al.* (2017) find that greater participation of women in farm positively influences their say

in decisions related to farming operations. Twyman *et al.* (2015) argues that the involvement of women in farm work signals their commitment and provides them with an 'earned right' and greater voice to engage in agricultural decision-making. In line with the arguments by Twyman *et al.* (2015), we hypothesise that increasing participation of women in farming should increase their autonomy in farm-related decision-making. This conjecture is all the more plausible as increased female participation in the farm would enable females to acquire the necessary skills and know-how to manage farm operations independently.

Our arguments are also in line with the predictions of the intra-household bargaining theory which states that women's participation in the labour market (as well as women's access to assets such as land) would increase their empowerment by improving their threat points or utility from the non-cooperative solution (Agarwal 1997). However, Anderson and Eswaran (2009) and Kantor (2003) make a distinction between women's unpaid work in the farm or home-based enterprises and market work, and argue that women's work in the farm does not influence their '*threat points*' and hence should have no effect on their say on overall household-related decisions.[2] The autonomy and the status of women in society may also be unchanging given rigid social norms and women's limited access to assets such as land (Radel *et al.* 2012).

3. Data and methods

3.1 Data and variable description

The study uses panel data from the Indian Human Development Survey (IHDS) conducted for the years 2004–2005 (IHDS-I) and 2011–2012 (IHDS-II) (Desai and Reeve 2015a, b). Both IHDS-I and IHDS-II are representative at the national level. While the rural sample for IHDS is based on stratified random sampling, the urban sample was drawn using a stratified sample of towns and cities within states selected by probability proportional to population sampling. We restrict our analysis to rural households who have at least one household member working in the farm. Further, because we use certain household-level variables from the IHDS-I (2004–2005) survey, we lose some observations due to sample attrition.

Indian Human Development Survey contains detailed individual, household and community-level information which we use for our analysis. Specifically,

[2] It is noteworthy that Anderson and Eswaran (2009) and Kantor (2003) consider women's autonomy in decision-making with regard to general household decisions such as those related to purchase of food, clothing etc. On the other hand, Twyman *et al.* (2015) and Anderson *et al.* (2017) consider decisions related to farming operations in particular. It can be argued that although women's participation in the farm does not influence their autonomy with regard to general household-related decisions, it has a positive influence on their say in farm-related decisions through the greater voice, skills and know-how they obtain from such participation.

we use information on participation and hours worked in the farm over the previous year by the household members as well as information on the gender of the primary decision-maker in the farm as our outcome variables. Additionally, IHDS contains information on income earned from a variety of sources. We aggregate income earned from non-farm business, remittances as well as agricultural and non-agricultural wage employment to arrive at the total non-farm income of the household. IHDS also contains detailed data on the demographic and socio-economic characteristics of the households. Finally, the data contain village-level information on occurrence on floods and droughts, local agricultural wage rates and village infrastructure.

3.1.1 Measures of agricultural feminisation and female autonomy in farming
Following de Brauw *et al*. (2008) and de Brauw *et al*. (2013), we use four measures of agricultural feminisation: firstly, we measure participation (for males and females separately) as a binary variable equalling one if the person works in the farm and zero otherwise; secondly, we use hours worked on the farm by males and females separately; thirdly, we consider the share of female household members out of all household members engaged in farming as a measure of feminisation; and fourthly, we consider a dummy variable equalling one if all household members engaged in farming are males and zero otherwise.

Recent literature has explored women's empowerment in agriculture using various indicators within a multidimensional framework (Alkire *et al*. 2013; Twyman *et al*. 2015). However, given the limitations of data, we use the gender of the primary decision-maker on the farm as a proxy for female autonomy in farming. Despite its limitations, we believe that such a measure should still provide us with an informative picture of women's empowerment and decision-making ability in Indian agriculture.

3.2 Descriptive statistics

Table 1 provides the definitions and descriptive statistics for the outcome variables of interest. Our summary statistics show household engagement in non-farm activities to be associated with the rising feminisation of agriculture. Non-farm participation also has contrasting gender implications with males withdrawing from farming and females increasing their labour contribution to farming as households diversify into non-farm activities. Finally, household diversification into non-farm activities is associated with an increase in female autonomy in farm-related decision-making (Table 1).

Table 2 (as well as Table S1) summarises and defines the independent variables used in the study. The primary independent variable of interest is the non-farm income of the household. Given the skewed nature of the variable, we log-transform the variable in further econometric specifications (*log_nonfarm_inc*). Important individual-level covariates affecting participation in the farm include age, gender and education. Given the influence of the

Table 1 Participation in farming and autonomy by non-farm activity

Variable	Description	Mean	
		Household does not participate in non-farm	Household participates in non-farm
Individual-level variables			
work_farm	= 1 if the individual works in the farm, else 0	0.54	0.55
work_farm (Male)†	= 1 if the individual works in the farm, else 0	0.65	0.62
work_farm (Female)‡	= 1 if the individual works in the farm, else 0	0.42	0.48
ln_farm_hrs§	Logarithm of hours of work in the farm	6.28	5.67
ln_farm_hrs (Male)†,§	Logarithm of hours of work in the farm	6.02	5.55
ln_farm_hrs (Female)‡,§	Logarithm of hours of work in the farm	6.45	5.77
Household-level variables			
hhld_sh_fem_farm	Ratio of the female household members engaged in farming to total household members engaged in farming	0.36	0.42
hhld_male_farm	= 1 if no female members engage in farming in the household, else 0	0.27	0.17
hhld_fem_autonmy	= 1 if the primary decision-maker in farm-related activities in the household is a female, else 0	0.07	0.11
No. of individuals	—	15,250	66,677
No. of households	—	3,019	12,425

Note: Statistics reported for individual-level variables are at the individual level; that is, the unit of analysis is the individual. For household-level variables, statistics are reported at the household level. †Estimations are conducted for male individuals only. ‡Estimations are conducted for female individuals only. §Statistics reported are based on individuals with positive hours of work in the farm. Source: Authors' calculations based on IHDS-II (2011–2012) data.

status of the family member in the household in labour force participation, we include separate dummies depicting relationship with the household head (Fafchamps and Quisumbing 2003). Further, we include standard household-level covariates affecting agricultural feminisation and female autonomy such as religion, caste, household agricultural and non-agricultural assets.

The study controls for household composition through the inclusion of variables measuring household head's age, the number of adult males and females as well as the proportion of minors and elderly in the household. An important correlate of female autonomy in the household is women's access to assets such as land (Agarwal 1997; Allendorf 2007; Wiig 2013). We accordingly proxy for women's land rights through a variable measuring female inheritance of land (*dmy_land_female*). Such a measure is also less

Table 2 Variable definitions and descriptive statistics

Variable	Description	Mean
Individual-level variables		
dmy_male	= 1 if the individual is male, 0 otherwise	0.50
Age	Age of the individual in years	29.75
yrs_school	Years of schooling of the individual	4.66
dmy_head	= 1 if the person is the head of the household, else 0	0.19
Household-level variables		
ln_nonfarm_inc†	Logarithm of total non-farm income of the household.	8.57
Hindu	= 1 if the household practices Hinduism, else 0	0.86
hhld_assets05‡	Number of consumer durables owned by the household	10.00
ln_land_own05‡,§	Logarithm of acres of land owned by the household in 2004–2005	1.17
dmy_land_female	= 1 if the household acquired most of its land through inheritance to female members, else 0	0.02
occ_head_fathr_prof¶	= 1 if the father/husband's father of the household head belonged to a professional or sales related occupation, else 0	0.03
occ_head_fathr_clrcd††	= 1 if the father/husband's father of the household head belonged clerical work related occupation or was an agricultural worker, else 0	0.25
occ_head_fathr_cultv‡‡	= 1 if the father/husband's father of the household head was a cultivator, else 0	0.72
vill_migr	Number of persons who left the village to find seasonal work during 2010–2011	97.23
yrs_place	= 1 if the family moved to the place <50 years ago, else 0	0.04

Note: Statistics reported are at the individual level; that is, the unit of analysis is the individual. Statistics reported are based on data from IHDS-II (2011–2012) unless otherwise mentioned. †Specifically, $ln\_nonfarm\_inc = \text{sign}(nonfarm\_inc) \times \ln\{\text{abs}(nonfarm\_inc) + 1\}$, where *nonfarm_inc* is the non-farm income of the household. sign(*nonfarm_inc*) is + 1 if $nonfarm\_inc \geq 0$ and −1 if $nonfarm\_inc < 0$; abs (*nonfarm_inc*) is the absolute value of *nonfarm_inc* and ln(.) gives us the natural logarithm of the argument. ‡Statistics reported are based on data from IHDS-I (2004–2005). §Specifically, $ln\_land\_own05 = ln(land\_own05)$ where *land_own05* denotes land owned in acres by the household in 2004–2005 and ln(.) gives us the natural logarithm of the argument. ¶This corresponds to two-digit NCO-1968 codes 0–29 and 40–49. ††This corresponds to two-digit NCO-1968 codes 30–39, 50–59, 60, 62–68 and 70–99. ‡‡This corresponds to two-digit NCO-1968 codes 61. Source: Authors' calculations based on IHDS-II (2011–2012) data.

likely to be contaminated by endogeneity concerns compared to direct indicators of women's land rights (Maluccio and Quisumbing 2003).

Given the important role of exposure to media in the provision of information and furthering women's empowerment, we include separate variable capturing women's (and men's) exposure to news media, radio and TV media (Jensen and Oster 2009). Finally, the study controls for village-level factors such as the occurrence of floods and droughts, village-level agricultural wages and conditions of labour shortage in the village.

3.3 Methods

The study uses regression methods to examine the relationship between agricultural feminisation and non-farm participation. However, an important econometric issue in estimating such a relationship is that decisions related to

farm and non-farm participation are likely to be made simultaneously. Further, unobserved individual and household-level characteristics may be correlated with both non-farm incomes and the outcome variable leading to omitted variable bias. Similar problems arise in estimating the model of female autonomy in farming. Following the existing literature, we make use of the instrumental variable (IV) approach to estimate our model (Mu and van de Walle 2011; Mendola and Carletto 2012).

As discussed in Section 3.1, the study attempts to measure agricultural feminisation using both binary and continuous variables. Accordingly, in case the outcome variable is binary, we model the impact of non-farm incomes on agricultural feminisation using an IV-probit specification, as follows:

$$\Pr(y_1 = 1|X) = \Phi(X\gamma). \tag{1}$$

Here, y_1 is a dummy variable denoting participation in the farm, Φ is the cumulative standard normal distribution, and X is the vector of independent variables including non-farm incomes which is the variable of interest (*ln_nonfarm_inc*). Other independent variables in the model include individual-level variables such as gender, age, education, marital status and dummies for a relationship with the household head. Additionally, we control for household-level factors such as religious and caste affiliation, household composition and access to agricultural and non-agricultural assets. We also control for labour market conditions in the village. Finally, we control for the macro-level socio-economic environment through the inclusion of state/province dummies. The two-step estimator proposed by Newey (1987) is used to estimate the model.

Similarly, in case the outcome variable is continuous such as hours worked in the farm or the share of farm work undertaken by women in the household, the model is estimated using a two-stage least squares (2SLS) specification as follows[3]:

$$y_2 = X\beta + u. \tag{2}$$

Here, y_2 is a continuous variable denoting either logarithm of hours worked in the farm or the share of farm work undertaken by women and X is defined as in Equation (1). The model is estimated using the two-step GMM estimator which offers efficiency gains over traditional 2SLS estimators under

[3] A critical problem is modelling participation using hours worked in the farm is that work hours are censored at zero. Given the criticism of the tobit model in modelling such outcome variables, we make use of the two-part model in our analysis (Dow and Norton 2003; Moffit 2004; Hertz 2009). Following the approach used in the two-part model, we estimate the hours worked equations conditional on participation in the farm, that is only for persons with positive hours of work.

possible violation of the homoscedasticity assumption (Cameron and Trivedi 2005).

Finally, female autonomy in farming is modelled using an IV-probit specification as in Equation (1), as follows,

$$\Pr(y_3 = 1|X) = \Phi(X\gamma). \tag{3}$$

Here, y_3 is a dummy variable equalling 1 if the primary decision-maker in the farm is a female and zero otherwise. Φ is defined as in Equation (1) and X is a vector of independent variables. Given our interest in studying the impact of agricultural feminisation on female autonomy, our independent variable of interest is the share of female household members out of all household members engaged in farming (*hhld_sh_fem_farm*). Other important covariates of interest include household non-farm income (*ln_nonfarm_inc*) and women's access to inherited land (*dmy_land_female*). Additionally, the model includes standard controls such as religious and caste affiliation of the household, household composition, access to agricultural and non-agricultural assets as well as state/province dummies.

Given endogeneity concerns with covariates such as non-farm income and female farm work in the above models, we rely on IV framework to estimate the effect of the potentially endogenous covariates on our outcome variables related to agricultural feminisation and female autonomy. Instrumental variables used in the study are summarised in Table 2 and discussed below.

3.3.1 Instrumental variables

We use the following variables to instrument for household non-farm income:

The first instrument that we consider is the occupation of the father/husband's father of the household head[4] (*occ_head_fathr_prof* and *occ_head_fathr_clrck*). The existing literature finds that father's occupation significantly influences both participation and income from non-farm activities (Lentz and Laband 1990; Emran and Shilpi 2011). However, conditional on the household engaging in farming and controlling for various individual, household and community-level characteristics, the occupation of the household head's father is unlikely to influence outcomes related to agricultural feminisation and female autonomy in farm-based activities.

Secondly, we use migrant networks defined as the number of seasonal migrants from the village in the year before the survey year (*vill_migr*) as an instrument of household non-farm income. Migrant networks are supposed to be highly correlated with remittances, an important component of non-farm income. Similar instruments have been widely used in the migration

[4] Specifically, we use the dummies *occ_head_fathr_prof* and *occ_head_fathr_clrck* to capture the occupation of the father/husband's father of the household head, with *occ_head_fathr_cultv* acting as the reference category.

literature (de Brauw 2010; Binzel and Assaad 2011; Mendola and Carletto 2012). Migrant networks are postulated to lower the costs and hazards of migration for households through the formation of extensive social and information networks that link the migrants in the destination with family and friends at home (de Brauw 2010; Mendola and Carletto 2012). However, controlling for individual, household and community-level characteristics, migrant networks should not directly affect our outcome variables.

Thirdly, we use the number of years ago the family moved to the current location as an instrument for household non-farm income (*yrs_place*). Households residing in the location for a longer period are supposed to earn higher incomes from non-farm sources through the accumulation of greater social capital and other channels. However, controlling for individual, household and community-level covariates, the number of years of residence in a place should not affect outcomes related to agricultural feminisation and female autonomy in farming.

Similarly, the study instruments for *hhld_sh_fem_farm* in Equation (3) using the number of adult males and females in the household (*hhld_n_adult_male* and *hhld_n_adult_female*). The number of adult males and females in the household is supposed to be highly correlated with *hhld_sh_fem_farm* but is not likely to affect female autonomy in farm-related decision-making except indirectly through *hhld_sh_fem_farm*.

4. Results and discussion

4.1 Instrument validity and relevance

Given the importance of the IVs for our identification strategy, we first report the results for the validity and the relevance of the IVs. The results for the weak identification tests show the instruments to be highly relevant and strong. The Kleibergen–Paap rk *F*-statistic in all cases exceeds the rule-of-thumb value of 10 as proposed by Stock and Yogo (2005) (Tables 3, 4). Further, the over-identification tests strongly support the validity of our instruments. Based on the results for Hansen's *J* test or the Amemiya–Lee–Newey test, we cannot reject the null hypothesis that the instruments are valid (Tables 3, 4).

However, the reliability of the over-identification test hinges on there being at least enough instruments to identify the 2SLS model exactly (Wooldrige 2010). In this regard, Murray (2006) argues that the credibility of the over-identification tests is enhanced if the instruments are different from each other in terms of their underlying logical reasoning and theoretical rationale. As such, the favourable results from our over-identification tests assume greater credibility in the light of the variety of instruments used in our study. We can also take further comfort from the fact that some of the instruments used in our study (such as *yrs_place* and *vill_migr*) have relatively much stronger

Table 3 Impact of non-farm income on farm labour participation

	Dependent variables					
	work_farm			*ln_farm_hrs*†		
	Total 1	Male 2	Female 3	Total 4	Male 5	Female 6
ln_nonfarm_inc	0.002	−0.083***	0.076***	−0.248***	−0.263***	−0.222***
Weak identification test (*F*-statistic)‡	189.40	96.18	94.78	106.83	61.27	45.67
Over-identification test (*P*-value)§	0.74	0.30	0.95	0.51	0.67	0.39
No. of observations	76,448	38,202	38,246	41,001	23,102	17,899

Note: Significant levels ***1%, **5% and *10% are based on robust standard errors. Additional control variables used in the model include individual, household and village-level covariates. See Tables S2–S7 for further results and details. †Estimates are based on data for individuals who have worked at least 1 h in the farm. ‡Statistic reported is the Kleibergen–Paap rk Wald *F*-statistic. §Statistic reported is the *P*-value corresponding to the Amemiya–Lee–Newey minimum chi-square statistic in case the outcome variable is binary (Columns 1, 2, and 3) and the *P*-value corresponding to the Hansen's *J* statistic in case the outcome variable is continuous (Columns 4, 5, and 6).
Source: Authors' calculations based on IHDS-I (2004–2005) and IHDS-II (2011–2012) data.

Table 4 Non-farm income, agricultural feminisation and female autonomy in farming

	Dependent variables		
	hhld_sh_fem_farm 1	*hhld_male_farm* 2	*hhld_fem_autonmy* 3
ln_nonfarm_inc	0.023***	−0.146***	0.020
hhld_sh_fem_farm	—	—	1.095**
dmy_land_female	—	—	0.610***
Weak identification test (*F*-statistic)†	39.46	39.46	39.65
Over-identification test (*P*-value)‡	0.65	0.69	0.33
No. of observations	14,338	14,338	13,315

Note: Significant levels ***1%, **5% and *10% are based on robust standard errors. Additional control variables used in the model include household and village-level covariates. See Tables S8–S10 for further details. †Statistic reported are for Kleibergen–Paap rk Wald *F*-statistic. ‡Statistic reported is the *P*-value corresponding to the Amemiya–Lee–Newey minimum chi-square statistic in case the outcome variable is binary (Columns 1 and 3) and the *P*-value corresponding to the Hansen's *J* statistic in case the outcome variable is continuous (Column 2). Source: Authors' calculations based on IHDS-I (2004–2005) and IHDS-II (2011–2012) data.

grounds to be considered as exogenous providing further credence to the over-identification test results.[5]

4.2 Econometric results

Table 3 reports the results for the impact of household non-farm diversification (HND) on labour participation in the farm. The study does not find any significant impact of household participation in non-farm activities on overall participation of the household member on the farm. However, looking at the impact of such non-farm diversification separately by gender provides interesting results. Whereas HND leads to more females participating in farming, the effect is the opposite for males (Table 3). The results concur with related literature on migration which finds migration of a household member leads to greater participation of women in farm and unpaid work (Binzel and Assaad 2011; Mu and van de Walle 2011; Mendola and Carletto 2012).

Further, HND significantly reduces hours worked on the farm for household members participating in farming. However, in line with our earlier results, we find that the reduction in hours worked farming is larger for male household members relative to females (Table 3). Such results are consistent with the hypothesis of HND leading to a feminisation of agricultural operations. Similar results were reported by de Brauw (2010) who find a larger negative effect of the migration of a household member on days worked on the farm for women relative to men.

[5] See the arguments provided by Murray (2006, p. 116) in regard to this contention.

The above results are supported by those reported in Table 4 which find a positive impact of HND on the share of household farm labour performed by women. Similarly, HND is found to significantly reduce the probability that no female members engage in farming in the household. The results unambiguously show HND to be a significant factor driving the feminisation of agriculture. Our results are robust to the use of alternative specification to measure the phenomenon of agricultural feminisation.

We further check whether the relation between HND and feminisation of agriculture differs by the household income status. The results show that the relationship between the HND and feminisation of agriculture is much stronger among low-income households relative to high-income households. Given social norms against the participation of women in work outside the household, the relatively higher participation of low-income women in farming in response to male mobility to non-farm work, we argue, signifies the compulsion for women's work in poor families for the survival of the household. The finding provides some evidence in favour of the distress-driven hypothesis of women's farm work (Table S11).

Finally, the study looks at the effect of agricultural feminisation and other factors on female autonomy in farming. Table 4 shows that increasing the share of household farm labour performed by women (*hhld_sh_fem_farm*) significantly improves the probability of a woman being the primary decision-maker in farm-related activities of the household. Our results align with Twyman *et al.* (2015) and Anderson *et al.* (2017) who find a positive influence of women's participation in farm work on their say in farm-related decision-making. However, controlling for *hhld_sh_fem_farm*, we do not find any significant impact of HND on female autonomy in farming. In line with the large literature on women's land rights and their empowerment, the study finds a significantly positive impact of women's land rights on their autonomy in farming (Table 4). Further results show women's exposure to the media to be an important factor in promoting women's autonomy in farming (Table S10: Column 2).

The results highlight the role of HND on changing gender roles as women take increasing farm responsibilities and men shift to non-farm work. Such transformation in the division of labour within the household conforms with existing social norms which disapprove of women's market work outside the farm. Further, the increase in women's autonomy in farming in response to agricultural feminisation is encouraging given its potentially favourable effects on farm technical efficiency as well as nutrition and schooling of the household members (Rao *et al.* 2019; Wouterse 2019). However, greater participation of women in agriculture may have its pitfalls in terms of their greater workload and may not be as emancipatory for women as argued in Anderson and Eswaran (2009) (Paris *et al.* 2005; Garikipati 2009).

5. Robustness checks

This section assesses the robustness of the results presented earlier through some sensitivity checks.

5.1 Corrections for selection bias

The results presented in the previous section discuss the relation between HND, agricultural feminisation and female autonomy in farming *conditional on the household being engaged in farming*. However, farm households may not be randomly selected from the overall population thus leading to a bias in our results. We attempt to correct for such bias using a method proposed by Heckman (1979). Specifically, we model household participation in farming for rural areas using a probit specification as follows:

$$\Pr(y_4 = 1|X) = \Phi(Z\gamma). \tag{4}$$

Here, y_4 is a dummy variable equalling one if the household engages in farming and zero otherwise. Φ is the cumulative standard normal distribution, and Z is the vector of independent variables. The vector Z contains the same household and village-level variables used to study agricultural feminisation or female autonomy in farming except for the endogenous variables (*ln_nonfarm_inc* and *hhld_sh_fem_farm*). Further, the vector Z contains the instruments used to identify the models for agricultural feminisation and female autonomy viz. *occ_head_fathr_prof*, *occ_head_fathr_clrck*, *vill_migr* and *yrs_place*.

Additionally, the vector Z includes a variable (which we call the selection instrument) which affects household engagement in farming but does not impact agricultural feminisation or female autonomy in farming. We consider the accessibility of the village by a paved road (*pucca_road*) as our selection instrument. Accessibility of the village by a paved road is supposed to impact farm engagement and exits by influencing the opportunities available for farmers for non-farm work, expectations about family life etc. (Bhandari 2013). However, the accessibility of the village by a paved road should have no effect on agricultural feminisation or female autonomy.

Estimates from Equation (4) are used to generate the inverse Mills ratio given by:

$$\lambda(Z\hat{\gamma}) = \phi(Z\hat{\gamma})/\Phi(Z\hat{\gamma}).$$

Here, $\phi(.)$ and $\Phi(.)$ are the standard normal distributions and the cumulative standard normal distributions, respectively, and $\hat{\gamma}$ are the co-efficient estimates from Equation (4). Finally, we re-estimate Equations 1–3 adding $\lambda(Z\hat{\gamma})$ as an additional regressor.

Consistent with our hypothesis, results from the first stage probit model show *pucca_road* to be a significant predictor of household engagement in farming.[6] Results for the bias-corrected model are available in Tables S2–S10 (Column 3). We also present the simple OLS/probit model estimates as the benchmark set of results (Tables S2–S10: Column 1). The results are similar to those in Tables 2 and 3 and show that the overall conclusions of the study to be robust to any correction for selection bias in our models.

5.2 Alternative measures of non-farm diversification and agricultural feminisation

In our second robustness check, we consider alternative measures of HND and agricultural feminisation. Specifically, we consider the dummy variable *work_nonfarm* as an alternative indicator of HND (See Table S1). Such an indicator is based on household member's participation in non-farm activities and hence is less likely to be affected by underreporting errors inherent in our measure of non-farm income. Similarly, we consider *hhld_male_farm* as an alternative indicator of agricultural feminisation.

Given the fact that *work_nonfarm* and *hhld_male_farm* are binary variables, IV-probit models are not suitable to estimate Equations 1 and 3. Following Angrist (2001), we use 2SLS specifications to estimate our models in case our outcome variable is binary. The results for our estimations based on these alternative indicators are presented in Tables S2–S10 (Column 4). The results are similar to those discussed earlier in Section 4.2 and support the overall conclusions of the study.

5.3 Controlling for gender relations in the household

The results of the study show HND to be a significant factor in influencing the agricultural feminisation process. Given the importance of the IVs in our overall identification strategy, Section 4.1 provides extensive arguments in favour of the validity of the IVs. These arguments are more likely to be justified when we specify our outcome variable as female's share of household farm work (such as *hhld_sh_fem_farm* and *hhld_male_farm*). In such cases, even if the IVs affect participation in the farm, they remain valid as long as such an effect does not differ by gender. However, it might still be argued that some of our IVs such as the occupation of the father/husband's father of the household head are likely correlated with gender relations in the household which might also influence agricultural feminisation and female autonomy in farming. Similarly, the IVs *hhld_n_adult_male* and *hhld_n_adult_female* might affect gender relations within the household which can have an influence on female autonomy in farming.

[6] Results for the first stage probit model are not shown in the paper but are available upon request.

The study attempts to preclude such links between the IVs and the outcome variables by including controls for household gender relations in our models. Specifically, the study makes use of information on gender relations within the household from IHDS-I (2004–2005). For each household, IHDS-I asked an ever-married woman between ages 15 and 49 a number of questions related to their say on household decisions and other aspects of gender relations within the household. The study uses such information as a proxy for gender relations within the household. Table S1 provides the operationalisation and summary statistics for such variables.

The results for the specifications controlling for gender relations within the household are presented in Additional Tables S2–S10 (Column 5). The results are similar to those presented in Tables 3 and 4, and our overall conclusions remain robust to the inclusion of the controls for gender relations in the household.

6. Conclusion

The paper attempts to contribute to the limited literature on HND, agricultural feminisation and female autonomy in farming. The study unambiguously shows HND to be an important factor contributing to agricultural feminisation. The study finds some evidence that the phenomenon is distress driven. We also find such a phenomenon of agricultural feminisation to lead to greater female autonomy in farming. Another important factor influencing women's autonomy in farming is women's access to land rights. Our results are robust to the use of alternative measures of agricultural feminisation. Further robustness checks uphold the findings of the study bestowing greater credibility to our results.

The paper provides interesting insights into the role of HND on the farm economy. The results highlighting the importance of HND as an important driver of agricultural feminisation assume significance given the size and the growth of the sector in rural areas. Such rising prominence of the non-farm economy in rural areas should lead to greater engagement of women in farming as men shift to non-farm activities. Such changes in gender relations in agriculture can have potential consequences for the farm sector given women's limited access to agricultural assets (Food and Agriculture Organization 2011; Quisumbing *et al*. 2014). Such problems are compounded by difficulties related to the shortage of male labour, investment and hiring labour for female managed farms (Paris *et al*. 2005; Goldstein and Udry 2008; Radel *et al*. 2012; Djurfeldt *et al*. 2018).

Finally, although the favourable impact of agricultural feminisation on women's autonomy in farming is desirable, such a process can be a double-edged sword leading to a rising burden of work for women and restricting their scope for more empowering market work outside the farm (Paris *et al*. 2005; Garikipati 2009). Such phenomenon chimes well with the broader debate on the feminisation of responsibility and obligation as women

increasingly bear the double burden of care and market work for the survival of the household (Chant 2007).

The paper concludes with the following suggestions. Firstly, women's greater involvement in farm activities and decision-making calls for urgent measures to improve their access to agricultural assets such as land. Secondly, there is a need to collect sex-disaggregated data as well as combine both qualitative and quantitative data sources to get a better understanding of gender relations in agriculture (Quisumbing *et al*. 2014). Thirdly, greater efforts need to be made to lessen women's rising burden of work through, for example, greater state support for education, health and child care (Palriwala and Neetha 2012). Finally, further studies investigating the causes and consequences of agricultural feminisation are warranted.

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Supporting Information

Additional Supporting Information may be found in the online version of this article:

Table S1. Variable definitions and descriptive statistics.

Tables S2–S7. Impact of household non-farm diversification on farm labour participation.

Tables S8 and S9. Impact of household non-farm diversification on agricultural feminisation.

Table S10. Impact of household non-farm diversification and agricultural feminisation on female autonomy in the farm.

Table S11. The moderating role of household income in the relationship between non-farm participation and femnisation of agriculture.