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Revisiting The Decline In India's Female Labour Force Participation: The Rise Of Machines And Security Risks

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This article posits that the mechanisation of agriculture and security risks have significant negative effects on India's female labour force participation rate. Despite remarkable economic progress in India, aggregate female labour force participation rate still show a declining trend since the late 1970s and traditional explanations such as decreasing fertility rates, rising wages and education levels could not completely explain this trend in female labour force participation. Using time-series data from 1980, we find evidence that the share of agriculture to the GDP, the mechanisation of agriculture, and security risks are the key determinants of female labour force participation.

(JEL: J01, J20, J21)

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I. INTRODUCTION

Since the middle of the 20th century, many countries throughout the world experienced significant increases in female labour force participation. India, however, is a unique example as it has one of the lowest and continuously declining female labour force participation in the world. This, despite the fact that India continue to experience high economic growth rates since the 1990s. The rigid nature of gender inequality in education, employment and income; culture, traditions, low sex ratio, poor quality education and mismatch of skills, and lack of employment opportunities are touted as major hurdles facing labour force participation in India (see for example Kapsos et al. 2014; Sorsa et al. 2015; Das et al. 2015) . This decline in female labour force participation raises skepticism on the continued growth of the economy.

This study aims to revisit the factors affecting the aggregate female labour force participation in India since 1980. In doing so, we look at the structure of the Indian labour market, the status of women in general and also in rural and urban areas, education and health facilities, occupational segregation for men and women and the factors that influence women's decision making with respect to joining the labour force. Our basic premise is that labour force participation is not only an outcome of supply factors but just as importantly, demand for labour as well. We explore alternative factors that contribute to the decline in female labour force participation in India. Specifically, we examine the role of Indian agriculture and its mechanisation in affecting the division of labour between the two sexes in the rural areas, as well as the extent to which security risk for females affect labour force participation – a first, to the best of our knowledge in this literature. We hypothesise that as India's agriculture sector transitioned from manual to mechanical and from traditional to modern methods

of cultivation, demand for female workers decrease, at the same time, females are forced to withdraw from the labour force in rural areas. Further, as India's urban female labour force has been almost stationary since the last three decades, the net decline in the national female labour force participation comes from rural areas. We also hypothesise that security risks that discourage females from entering the labour force significantly affect the overall participation rate.

II. LITERATURE REVIEW

Female labour force participation has received considerable attention from labour, development economist and policy makers, especially since economic empowerment of women is considered crucial to growth (Klugman et al. 2014) and it is common consensus that education is the first step towards empowerment. The structural transition experienced by economies demands higher skills which in turn give higher returns, encouraging individual and institutions to invest in human capital (Heckman, 2000; Blöndal et al. 2002). Goldin (1995) argues that the correlation between economic development and female labour force participation changes with the level of development. She suggests that correlation would take a U-shape – that female labour force participation exhibits a downward trend in the beginning of the development process due to a transfer from home production or domestic duties to the formal labour market which require human capital skills. However, uneducated or low educated women can only do labour or manual work in their family farm, which carries a strong social stigma, e.g., manual work is socially undesirable, therefore women are more likely to opt out of the labour force. Further, during the early development stage, education opportunities expand for females, and this, along with increasing returns to education, encourages the illiterate and low skilled female labour force away from the labour market towards gaining an education. She concludes that as the economy

develops further with more females gaining education, increasing their ability to compete for higher positions, female labour force participation rate begins to rise and this contributes to the upward portion of the U-shape. Sundaram and Venneman (2008) find a positive relationship between literacy level of females and labour force participation.

Das and Desai (2003), Gaddis and Klasen (2014) and Lahoti and Swaminathan (2013), among others, raise questions on the validity of the U-shaped hypothesis. Das and Desai (2003) state that female labour force in India has not experienced feminisation like other South East Asian countries, since for several decades, they remained at the bottom of the U-shape despite substantial growth in GDP. They investigate the labour market behavior of educated women aged 20-55 years in India, using data from the National Sample Survey (NSS) for 1993-1994. They test the structural opportunity hypothesis through socio-economic status, education level of villages and blocks, which are expected to affect the labour market decision of women. They use caste as a proxy for cultural values. They also use an interaction term for caste and education. The dependent dummy variable is employment status. Their results show that education has a negative effect on labour participation, while lower caste people with children under five years of age are more likely to be employed. These findings appear contrary to the general literature, but in India, lower caste women work because they need to. Further, women are less likely to be employed despite having an education due to increasing competition for jobs. This is consistent with the previous literature and they imply that education must be accompanied by growth in employment opportunities. The interaction terms also show that lower caste educated women are less likely to be employed.

Gaddis and Klasen (2014), using data on female labour force participation from a variety of sources like the International Labour Organisation's estimates and projections and from different versions of the Penn World Tables (revisions 4th, 5th, and 6th of PWT versions 6.3 and 6.7), find that the U-shaped hypothesis motivated by secular patterns of structural change is weak or solely dependent on the data used for the analysis.

Similarly, Lahoti and Swaminathan (2013) re-examine the U-shaped hypothesis in the context of the Indian economy. They use state level panel data (1983-2010) to investigate the relationship between economic development and female labour force participation rate. Their methodology and estimation techniques are similar to Gaddis and Klasen (2014), and they found no evidence for the U- shaped relationship between economic growth and female labour force participation rate. Their results show that the decline in the female labour force participation in India does not show any sign of upturn with higher growth. They claim that economic growth is not accompanied by employment growth. Moreover, their results indicate that the Indian economy appear to have bypassed the manufacturing sector in its structural transition. India experienced a sharp decline in the share of value added by the agriculture sector while the manufacturing sector did not show any significant increase in its share. The service sector has emerged as the largest contributor to growth. However, the service sector requires skills for which majority of women are not trained due to social, cultural and traditional constraints. The unbalanced sectoral growth, lack of quality education, social and religious constraints are some hurdles in the way of not only a better socio-economic status for women, but participation in the labour market as well.

Klasen and Pieters (2015) attempt to identify the forces that cause the stagnation of female labour force participation rate in urban India since late 1987. They use micro

level data from 1987 to 2011. They limit their sample to married women aged 25-54. They suggest that a combination of demand and supply side factors contribute to the stagnation of female labour force participation. Male income and education reduces female labour force participation. The positive effect of higher education (tertiary) is moderated by opposing factors like social constraints. They also claim that the counteractive effect of social stigma seems to decline from 2009. On the other hand, demand side structural change could not create enough employment opportunities to absorb a growing female working-age population. Employment growth in urban India is confined to construction and low-skilled services, which benefitted men due to the stigma effect for women in low-skilled jobs. Ghani et al. (2013) suggest that political empowerment of women is a useful tool to increase both the demand for and supply of labour market opportunities for women. It can be a potential policy tool to tackle the declining trend of female labour force participation in India. They examine the direct (allocating more employment to women in public works) and indirect (facilitating female labour force participation) effect of female political representatives on labour market outcomes. They claim that an additional year of exposure to female political representatives across all local government levels increase the female labour force participation by 17.5%. Moreover, having a female leader at district level increases this outcome by 8%.

Neff et al. (2012) examine the decline in female labour force participation in rural India from 2004 to 2010 using NSS data. They find that the working age 15-24 constitutes only 29% of the total labour force because most in this age group are in school/university. The same trend is observed for urban women, and education appears to be a strong reason for the decline in labour participation. Their analysis further indicates that the income effect from male income reduces the supply of female labour.

They find no evidence that employment opportunities and social and cultural factors affect the declining labour force participation; hence they conclude that the decline is mainly due to the income effect (from male income) and partially due to education.

Sorsa et al. (2015) state that employment opportunities in agriculture have declined in India, and other low skilled jobs benefit men. Moreover, education (except tertiary) and labour force participation rate are negatively related. The study analyses the various determinants of female labour force participation under four broad categories: individual characteristics, household characteristics, district characteristics and state characteristics by using various rounds of data conducted by the National Sample Survey Organization (NSSO). Their regression results show that socio-cultural factors like marriage has a stronger negative effect on the labour force participation of women; Muslim women are less likely to enter the labour force while Christianity has a positive influence on female participation. The negative effect of a husband's income appears to diminish from 1987 to 2012 but remains negative nonetheless. Household head with a university degree lowers the probability of female participation by five percentage points in rural areas, and by 13 percentage points in urban areas. Number of children and labour force participation are negatively correlated, but only for urban women. It is common that parents and parents-in-law decide the female's role in the family and the labour market and the results show that the family has a strong negative influence on females' labour market decisions. Access to financial services like having a personal bank account and access to credit, etc. increases the female labour force participation by 0.22 percentage points.

III. THEORETICAL FRAMEWORK

The key aim of our study is to investigate different dimensions of female labour force supply and demand. We focus on studying how sectoral transformation contributes to

the decline in the female labour force participation. We develop our study based on the neoclassical model of supply and Becker's Household Model (1991) to grasp the behaviour of individuals and households in labour market decisions. We also adopt Boserup's (1970) theory in understanding the role of women in economic development, which in turn helps determine the demand for labour.

Neoclassical Model of Labour Supply

The basic neoclassical model of labour supply deals with individual labour supply decisions and is not influenced by other individuals. Becker (1991) expanded the neoclassical model of labour supply in two ways by considering a household perspective and allowing for multiple uses of time and time usage for commodities. The model assumes the household as the decision-making unit, rather than the individual. Decision-making is interdependent and influenced by the activities of other family members. Family members maximise their utility subject to time and budget constraints. A female's decision to work may depend on whether the male members are employed. The whole idea of the model revolves around the comparative advantage and gains from specialisation, i.e., that every agent should specialise in that good or service which it can produce at a relatively lower cost. The theory suggests that utility can be maximised when family members specialise in market or household production according to their comparative advantage. The model explains that division of labour by gender in all the societies is partly due to gains from specialisation and comparative advantage and partly due to biological differences. Women are biologically committed to production and feeding of children. Consequently, biological differences explain why women invest in human capital that raises household productivity with respect to caring for children. Conversely, men spend most of their working time in the market, so they invest in

capital that raises their market efficiency. If all the members allocate their time to their specialised sector, the total returns to the household will be higher.

However, while the decision to work outside the home is a household decision, Sudarshan and Bhattacharya (2009) observed that safety concerns are also a key factor influencing female participation in the labour market. Due to numerous reports of crimes against women, women feel uneasy about joining the workforce and leaving the security of their home. Mobility and safety concerns are frequently cited as huge obstacles to working, and must also be factored in the analysis.

Boserup's Theory: Women's Role in Economic Development

In regions of plough cultivation, the division of labour between the two sexes was due to shifting cultivation practices. The main farming instruments, like the plough was used with big animals like the ox, were used by men and women were relegated to manual farm work without any tools or implements. Most of the Asian regions in Boserup's sample show male dominance in agriculture because a large number of women were also exempted from work in the fields (for religious reasons or tradition in some societies), and women perform only domestic duties.

Boserup also looks at reasons why employers prefer male workers in industries. Laws that provide obligatory benefits for female workers, e.g., maternity leave, not permitted to work at night and in underground mines, result in preference for males in the bigger industries, because it appears more profitable to employ male workers (without as many mandated benefits) than female workers. Women also appear to prefer flexible working hours, which is possible in home or cottage industries where they are able to carry out domestic duties in between work hours. In many developing countries, working in home industries is also preferred to avoid contact with men from outside their own household.

In India and Pakistan for instance, factory work is not regarded as respectable work for women. These cultural and personal preferences lower the position of women in the labour market.

Boserup observes that in many developing countries, women are rarely trained for skilled jobs while male workers undergo vocational and on the job training. Women are considered as the weaker sex in the society, so they are unsuitable for work in heavy industries and are unable to work for longer hours. As a result, men hold most of the skilled jobs in industry and trade. Moreover, migration from rural to urban areas causes changes in women's activities. Subsistence activities in urban areas often disappear as a large part of home-produced goods is replaced by purchases from the market. Women, having no modern skills for industries (in the urban areas) are therefore confined to domestic activities; hence, female labour force participation is higher in rural areas than in urban areas. This kind of labour force participation is observed in India and Africa.

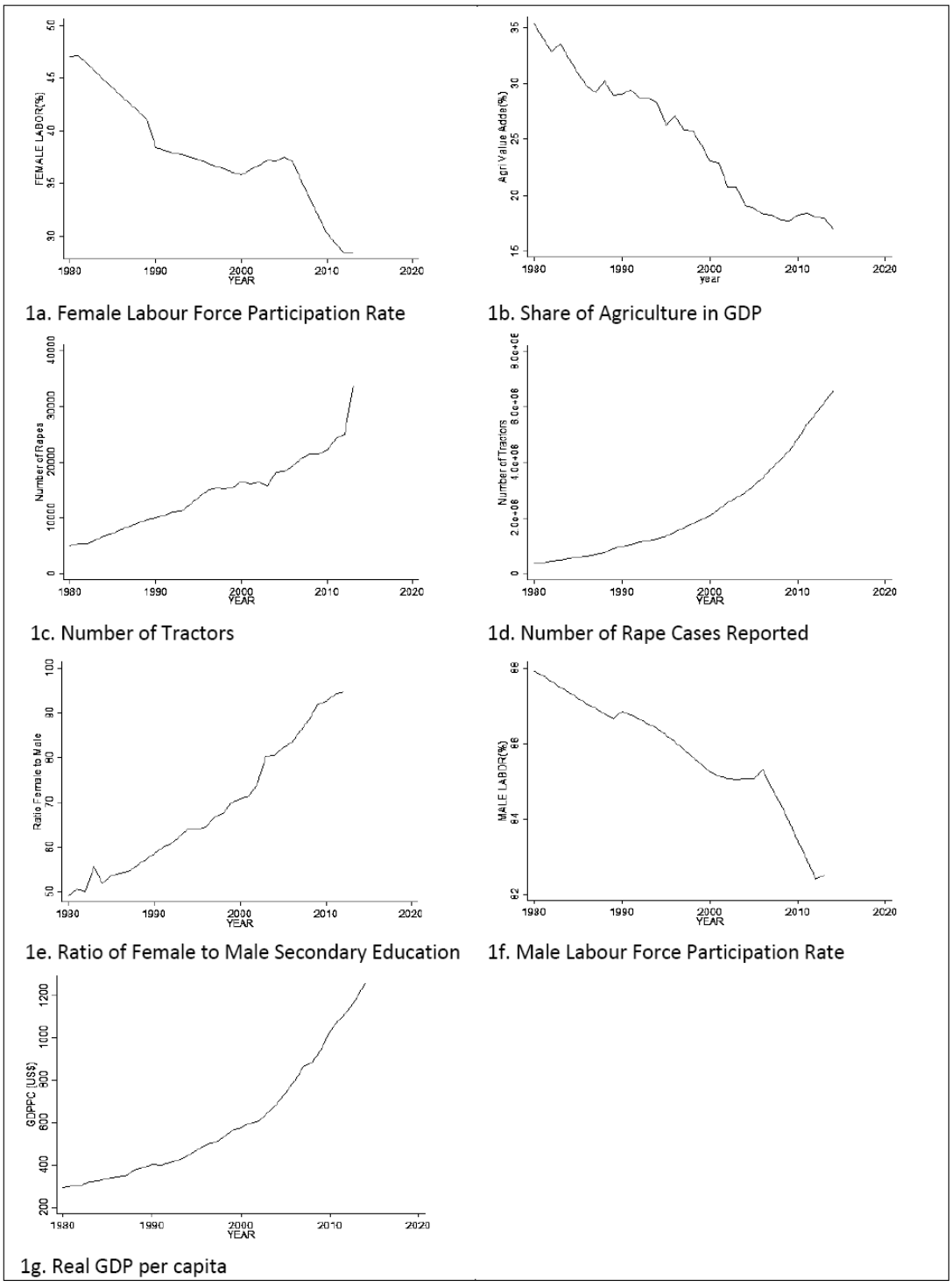
Boserup's idea that women are intrinsically inferior workers remains dominant in developing and developed countries. As a result, women seek security by escaping competition with men by sticking to more "feminine" professions (like teaching, secretarial work, etc.). Developing countries have launched programs to train women in crafts (e.g., hand-spinning in India) which may be first entry step into the labour market. However, this kind of program does not prepare women to compete in modern labour markets where employers seek more skills. This is particularly important as farming in India becomes more mechanised, farm labour in general tends to be displaced (see for example, Reddy et al. 2014); and if females are less skilled in the use of farm machinery, then we would expect demand for female labour to decrease as a consequence.

IV. DATA

We analyse the aggregate female labour force participation rate in India by using data from the World Development Indicators, International Labour Organisation and the National Crime Records Bureau of India. We use time series data from 1980 to 2013. Based on the previous review of literature, our analysis examines how the mechanisation of agriculture and the number of rape cases reported during the period of 1980-2013 can be important determinants of female labour force participation in India, controlling for the percentage share of agriculture to GDP, the ratio of female to male secondary education, female labour force participation rate, male labour force participation rate and real GDP per capita as important determinants of female labour force participation. A plot of each variable in levels is depicted in Figure 1.

- Female labour force participation rate (*FLPR*): Female labour force participation rate is the centre of our analysis. We collected labour force data from ILO and WDI (2007). According to ILO, the labour force participation rate is calculated by expressing number of persons active (employed or looking for work) in the labour market as a percentage of the working age population. In our analysis, the age range is 15-64 years. The female labour force participation rate in India has declined from 47.11% in 1980 to 28.5% in 2013.
- Agriculture value added percentage of GDP (*AVA*): Share of value added is an explanatory variable in our analysis. The *AVA* data is obtained from the World Bank database. The share of agriculture in India has declined by 19% since 1980. The average growth rate during this period is 3.5% which is mainly driven by the mechanisation of agriculture and use of high yielding crop varieties.

FIGURE 1.
Variables in levels.



1a. Female Labour Force Participation Rate

1b. Share of Agriculture in GDP

1c. Number of Tractors

1d. Number of Rape Cases Reported

1e. Ratio of Female to Male Secondary Education

1f. Male Labour Force Participation Rate

1g. Real GDP per capita

- Mechanisation of Agriculture (*MECH*): We are using the number of tractors as a proxy for the mechanisation of agriculture. The data is consolidated from WDI (2007) and Mehta et al. (2014).

- Number of Rape Cases Reported (*RISK*): We include the number of rape cases reported as a proxy for security risks and safety concerns facing working women. The data is available from the National Crime Records Bureau of India. We assume rapes as a suitable proxy for risks because these incidents are the root cause of fear and create a feeling of insecurity in society for females. Security risks lead the households to constrain women from entering the labour market.
- Male labour force participation rate (*MLPR*): We include *MLPR* as a control variable. We believe that more males in the labour market negatively affects female labour force participation rate. Moreover, the employed male could also indicate some information about these household head's income which is negatively correlated with *FLPR*.
- Ratio of female to male secondary education (*EDU*): Education is another control variable. We prefer to use the ratio of female to male secondary education to capture the effect of male and female education on *FLPR*. The literature suggests that female education (up to secondary schooling) has a negative effect on male education. On the other hand, the rising number of educated males indicates that males are able to capture more opportunities as evidenced by the dominance of males in the labour market and preference of employers for male employees. The number of females in secondary education is lower than males but it is improving due to rising returns to education. The ratio rose from 49% in 1980 to 95% in 2013.
- Real GDP per capita (*RGDPC*): We also include income to control for the general economic condition of India.

It is evident from Figure 1 that each variable (in level) exhibits a trend, and could possibly be non-stationary. For instance, female labour force participation rate (Figure 1a) and the share of agriculture in GDP (Figure 1b) are rapidly declining; the male labour force participation rate (Figure 1f) shows a sluggish decline; the number of tractors (Figure 1c) – a proxy for mechanisation of agriculture, the number of rape cases reported (Figure 1d) – a proxy for security risks. the ratio of female to male secondary education (Figure 1e) and real GDP per capita (Figure 1g) all exhibit a rising trend.

Hendry (1980) warns about using OLS for non-stationary series. OLS requires all variables to be stationary otherwise the results will be spurious regressions. There is a possibility that two unrelated series are highly correlated and significant but one must remain cautious of an irrelevant relation between them. Therefore, we test our variables of interest according to their nature.

V. ANALYSIS

Testing for time series properties

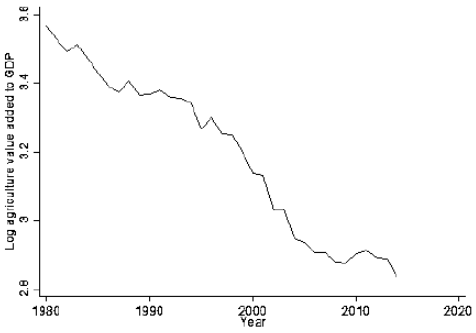
Elder and Kennedy (2001) suggest that regressing two variables with unit roots give us spurious results with misleading t-statistics and R-squares and very low Durbin- Watson statistics. To avoid misleading results, we test the variables for unit roots.

A time series is stationary if its joint distribution is time invariant, i.e., the mean and variance do not depend on time. Stationarity is determined by order of integration. If a variable is of zero order of integration, it is stationary or I(0), and if it is of higher order of integration, it is non- stationary. Traditional econometric techniques suggest that we need to difference the variable to get stationarity. The order of integration depends on how many times we need to difference the variable to it make it stationary. We use the

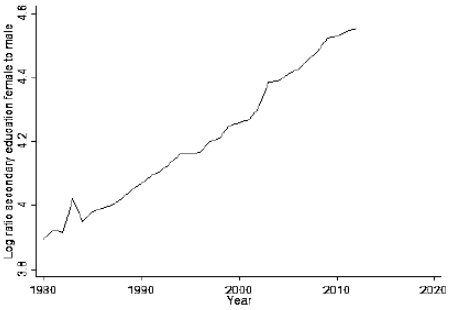
Augmented Dickey Fuller (ADF) (Dickey and Fuller, 1981) test for unit roots and the Schwarz' Bayesian Information Criterion (SBC) to select the maximum number of lags. The plot of each variable below (Figure 2) exhibits an obvious upward or downward trend. The variables *lnAVA* (log share of agriculture in GDP) and l*nFLPR* (log female labour participation rate) are declining; *lnMLPR* (log male labour force participation rate) shows a small decline and the remaining three: *lnEDU* (log ratio of female to male sec education), *lnRISK* (security risks), *lnMECH* (log number of tractors) and *lnRGDPC* (log of real GDP per capita) display an upward trend. Based on these observations, we use an autoregressive equation with constant and trend for each variable for testing for unit roots.

The results from the ADF tests (Table 1) show that all the variables are I(1) and their first differences are I(0).

FIGURE 2.
Variables in logs.

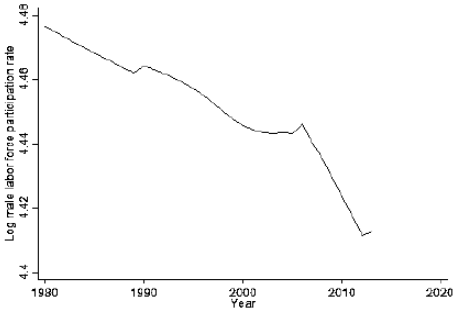


Log agriculture value added to GDP

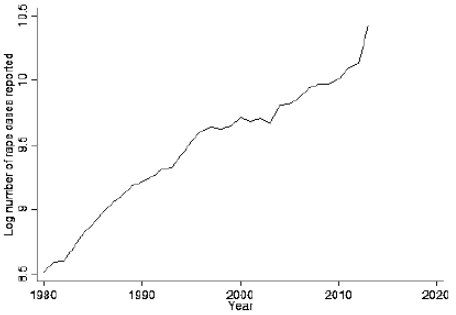


Log female: male secondary education

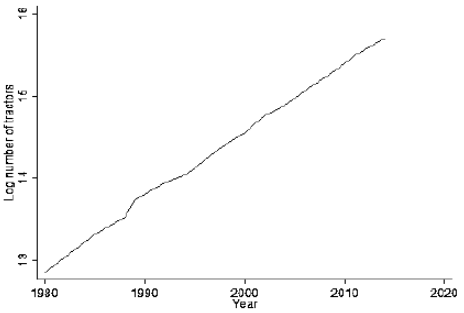
Log female labor force participation rate



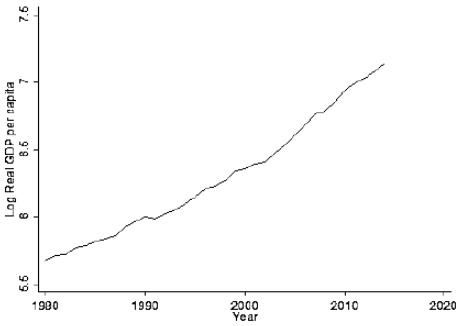
Log male labor force participation rate



Log number of rape cases reported



Log number of tractors



Log real GDP per capita

TABLE 1.

ADF Unit Root Test Results

Variable	Levels	First Difference	Order
lnAVA	-1.845	-3.295**	I(1)
lnFLPR	-0.688	-2.822**	I(1)
lnMLPR	-0.214	-3.196**	I(1)
lnEDU	-1.642	-9.472***	I(1)
lnRISK	-1.889	-4.126**	I(1)
lnMECHAGRI	-2.884	-5.620***	I(1)
lnRGDPC	-0.761	-3.564	I(1)

Notes:

*** and ** reject the null hypothesis at the 1% and 5% significance level based on McKinnon asymptotic (1990, 2010) critical values.

Since all the individual variables are non-stationary, we check for cointegration using Engle and Granger's two-step method (Engle and Granger, 1987). This method is based on ADF test and OLS regressions. The residuals are obtained from the OLS regressions. ADF tests are then conducted on the OLS residuals. Our OLS model for labour force participation is as follows:

$$lnFLPR_t = \alpha_1 + \beta_1 \ln AVA_t + \beta_2 lnEDU_t + \beta_3 lnMLPR_t + \beta_4 lnRISK_t + \beta_5 lnMECH_t + \beta_6 lnRGDPC_t + u_t \quad (1)$$

$$u_t = lnFLPR_t\alpha_1 - \beta_1 lnAVA_t - \beta_2 lnEDU_t - \beta_3 lnMLPR_t - \beta_4 lnRISK_t - \beta_5 lnMECH_t - \beta_6 lnRGDPC_t \quad (2)$$

The obtained residuals are regressed on their lagged term as follows:

$$u_t = \alpha u_{t-1} + \varepsilon_t \quad (3)$$

The null H0: $\alpha = 1$ implies that u_t is I(1), i.e., there is no cointegration. Alternative H1: $\alpha < 1$ implies that u_t is I(0), i.e., cointegration exists.

The different lag selection criteria (LR, AIC, HQIC and FPE) suggest the use of two lags to test for cointegration.

The Engle Granger tests (Table 2) do not reject the null, implying that there is no cointegration between *LFPR* and the explanatory variables, hence, we use a Vector Auto Regression (VAR) model for estimating the female labour force participation rate in India.

TABLE 2.

Engle Granger Test for Co-integration

Variable	Test statistic	1% Critical Value	5% Critical Value	10% Critical Value
Z(t)	-2.588	-6.499	-5.617	-5.193

Notes:

Critical values are from McKinnon (1990, 2010).

Var estimation

VAR estimation requires stationary time series but since our variables of interest are I(1), we conduct our VAR analysis on first differences. Two lags are incorporated in the model following the AIC and HQIC lag selection criterion. The following models are specified:

$$\Delta lnFLPR = \propto_1 + \beta_{11}\Delta \text{lnFLPR}_{t-1} + \beta_{12}\Delta lnFLPR_{t-2} + \beta_{13}\Delta lnMLPR_{t-1} + \beta_{14}\Delta lnMLPR_{t-2} + \beta_{15}\Delta lnEDU_{t-1} + \beta_{16}\Delta \text{lnEDU}_{t-2} + \beta_{17}\Delta lnAVA_{t-1} + \beta_{18}\Delta lnAVA_{t-2} + \beta_{19}\Delta lnRISK_{t-1} + \beta_{110}\Delta \text{ln}RISK_{\text{t}-2} + \beta_{111}\Delta lnMECH_{t-1} + \beta_{112}\Delta lnMECH_{t-2} + \beta_{113}\Delta lnRGDPC_{t-1} + \beta_{114}\Delta lnRGDPC_{t-2} + \varepsilon_{1t} \quad (4)$$

$$\Delta lnAVA = \propto_2 + \beta_{21}\Delta \text{lnAVA}_{t-1} + \beta_{22}\Delta lnAVA_{t-2} + \beta_{23}\Delta lnMLPR_{t-1} + \beta_{24}\Delta lnMLPR_{t-2} + \beta_{25}\Delta lnEDU_{t-1} + \beta_{26}\Delta \text{lnEDU}_{\text{t}-2} + \beta_{27}\Delta lnFLPR_{t-1} + \beta_{28}\Delta lnFLPR_{t-2} + \beta_{29}\Delta lnRISK_{t-1} + \beta_{210}\Delta lnRISK_{t-2} + \beta_{211}\Delta lnMECH_{t-1} + \beta_{212}\Delta lnMECH_{t-2} + \beta_{213}\Delta lnRGDPC_{t-1} + \beta_{214}\Delta lnRGDPC_{t-2} + \varepsilon_{2t} \quad (5)$$

We specify a similar model for the rest of the variables.

Equation (4) is our model of interest. We expect female labour force participation rate (*FLPR*) to be negatively correlated with the ratio of female and male secondary education (*EDU*) , male labour force participation rate (*MLPR*), past values of security risks (*RISK*) and the mechanisation of agriculture. On the other hand, we expect positive coefficients on real GDP per capita and the share of agriculture in GDP because the agriculture sector contribution to GDP is rapidly declining.

Granger causality

We perform Granger causality tests to investigate reverse causality in the variables of interest. Granger causality examines whether past values of one or more variables cause another variable. In other words, the test determines whether past values of one variable can help in the prediction of another variable in the model. For example, in equation (4), a significant β coefficient rejects the null of no causality and we conclude that that particular variable Granger-causes *LFPR*. For bi-directional causality, the coefficients of the two variables being analysed in the presence of other factors (i.e., other regressors) should be jointly significant.

The results from the Granger causality tests (Table 3) show that we cannot reject the null that dln*AVA* dln*MLPR* and dln*RGDPC* do not Granger-cause dln*LFPR*, i.e., that changes in the share of agriculture in GDP, male labour participation rate and real GDP per capita do not help us predict changes in the female labour force participation rate. On the other hand, we find that education, security risk, and mechanisation of agriculture Granger-causes female labour force participation. However, the results show that jointly, causality runs from all the explanatory variables to female labour force participation. The models for dln*AVA,* dln*EDU* and dln*MLPR* show that causality runs from the change in female labour force participation to the change in share of agriculture in GDP, education and male labour force participation.

TABLE 3.

Granger Causality Test Results (H0: no causality)

Equation	Excluded	Chi2	Df	Prob>chi2
dlnLFPR	dln*AVA*	4.8258	2	0.090
dlnLFPR	dln*EDU*	11.228	2	0.004
dlnLFPR	dlnRISK	8.3857	2	0.015
dlnLFPR	dlnMLPR	5.2721	2	0.072
dlnLFPR	dlnMECH	35.202	2	0.000
dlnLFPR	dlnRGPDC	3.0016	2	0.223
dlnLFPR	ALL	75.196	12	0.000
dln*AVA*	dlnLFPR	16.06	2	0.000
dln*AVA*	dln*EDU*	0.9086	2	0.635
dln*AVA*	dlnRISK	0.9550	2	0.620
dln*AVA*	dlnMLPR	2.6067	2	0.272
dln*AVA*	dlnMECH	4.2176	2	0.121
dln*AVA*	dlnRGPDC	0.6938	2	0.707
dln*AVA*	ALL	23.341	12	0.025
dln*EDU*	dlnLFPR	8.5752	2	0.014
dln*EDU*	dln*AVA*	0.1785	2	0.915
dln*EDU*	dlnRISK	35.784	2	0.000
dln*EDU*	dlnMLPR	1.7474	2	0.417
dln*EDU*	dlnMECH	0.8043	2	0.669
dln*EDU*	dlnRGPDC	5.6244	2	0.060
dln*EDU*	ALL	55.671	12	0.000

TABLE 3 (continued)

Equation	Excluded	Chi2	Df	Prob>chi2
dlnRISK	dlnLFPR	1.0931	2	0.579
dlnRISK	dln*AVA*	2.5473	2	0.280
dlnRISK	dln*EDU*	1.0245	2	0.599
dlnRISK	dlnMLPR	2.0557	2	0.358
dlnRISK	dlnMECH	3.1987	2	0.202
dlnRISK	dlnRGPDC	1.7832	2	0.410
dlnRISK	ALL	18.195	12	0.110
dlnMLPR	dlnLFPR	9.3229	2	0.009
dlnMLPR	dln*AVA*	3.2435	2	0.198
dlnMLPR	dln*EDU*	8.4563	2	0.015
dlnMLPR	DlnRISK	9.5863	2	0.008
dlnMLPR	dlnMECH	12.248	2	0.002
dlnMLPR	dlnRGPDC	4.4719	2	0.107
dlnMLPR	ALL	44.435	12	0.000
dlnMECH	dlnLFPR	0.07432	2	0.964
dlnMECH	dln*AVA*	0.77239	2	0.680
dlnMECH	dln*EDU*	1.0405	2	0.594
dlnMECH	dlnRISK	0.9177	2	0.632
dlnMECH	dlnMLPR	0.20659	2	0.902
dlnMECH	dlnRGPDC	2.5984	2	0.273
dlnMECH	ALL	8.3297	12	0.759

TABLE 3 (continued)

Equation	Excluded	Chi2	Df	Prob>chi2
dlnRGDPC	dlnLFPR	2.6859	2	0.261
dlnRGDPC	dln*AVA*	5.6544	2	0.059
dlnRGDPC	dln*EDU*	1.2876	2	0.525
dlnRGDPC	dlnRISK	10.682	2	0.005
dlnRGDPC	dlnMLPR	4.8787	2	0.087
dlnRGDPC	dlnMECH	18.63	2	0.000
dlnRGDPC	ALL	37.474	12	0.000

VI. RESULTS AND DISCUSSION

Estimation of the VAR model (Table 4) for female labour force participation rate shows that the sign of the coefficients on the lagged dln*AVA* are contrary to our hypothesis and they are not significant. The coefficient on the education variable (dln*EDU*) at lag one is negative, as expected, and significant at the 5% level. We find that a 1% change in the ratio of female and male secondary education causes a 26% decline in the change in female labour participation rate. The relationship between male and female labour force participation rate is negative but it is marginally significant at the 10% level. Mechanisation of agriculture has a negative impact on female labour force participation rate. Mechanisation of agriculture causes a 28% decline in the change in female labour force participation rate in India. This finding is consistent with the results of a study by Reddy et al. (2014), which show that mechanisation in the farm replaces labour.

We test the model for stability and for autocorrelation of the residuals. We examine whether or not the eigenvalues lie inside the unit circle. In other words the modules should be less than 1. We find that the VAR system is stable as the eigenvalues

stability condition is met as the modules for all eigenvalues are less than 1. We also perform the Lagrange–Multiplier Test to examine autocorrelation of the residuals, and find that there is no autocorrelation in the residuals.

Our results show that the mechanisation of agriculture has played a negative role in explaining female labour force participation in India. We have examined both the demand and supply side hypotheses.

- *Demand side Hypothesis*: That the declining share of agriculture in GDP leads to lower employment opportunities for females. In particular, there is less demand for females who perform manual because of the mechanisation of agriculture. Our study supports this mechanisation hypothesis.
- *Supply side Hypothesis*: That security risks that limit freedom of movement of females (e.g., fear of being raped while on the way to/from work) discourages female labour force participation. Moreover, both male and female education and male labour force participation rates have negative impacts on female labour force supply. The research presented above supports the security risks and education effect hypotheses.

TABLE 4.

VAR results

Dependent/ Independent Variables	dln*LFPR*	dln*AVA*	dln*EDU*	dln*RISK*	dln*MLPR*	dln*MECH*	dln*RGDPC*
L.dln*LFPR*	0.986***	-1.598***	-0.529*	-0.654	0.064**	0.126	-0.407
	(0.161)	(0.447)	(0.269)	(0.642)	(0.021)	(0.468)	(0.281)
L2.dln*LFPR*	-0.086	-0.024	0.754**	0.170	-0.023	-0.078	-0.002
	(0.159)	(0.441)	(0.266)	(0.633)	(0.021)	(0.462)	(0.277)
L.dln*AVA*	0.022	-0.518**	-0.026	0.389	-0.015	0.159	-0.270*
	(0.070)	(0.195)	(0.117)	(0.279)	(0.009)	(0.204)	(0.122)
L2.dln*AVA*	-0.142	0.108	0.034	-0.109	-0.011	-0.038	0.034
	(0.071)	(0.196)	(0.118)	(0.282)	(0.009)	(0.206)	(0.123)
L.dln*EDU*	-0.265**	0.096	-0.782***	0.357	0.025*	-0.164	0.172
	(0.089)	(0.247)	(0.149)	(0.354)	(0.012)	(0.258)	(0.155)
L2.dln*EDU*	-0.044	-0.101	-0.302*	0.207	0.029*	0.059	0.115
	(0.078)	(0.218)	(0.131)	(0.312)	(0.010)	(0.228)	(0.137)
L.dln*RISK*	0.090*	-0.099	-0.391***	0.095	0.006	0.101	-0.251***
	(0.044)	(0.122)	(0.074)	(0.175)	(0.006)	(0.128)	(0.077)
L2.dln*RISK*	-0.127*	0.098	-0.192*	0.142	0.020*	0.070(0.1	0.050
	(0.055)	(0.153)	(0.092)	(0.220)	(0.007)	61)	(0.096)
L.dln*MLPR*	-2.480*	5.210	-1.970	6.622	0.163	0.656	4.099*
	(1.173)	(3.257)	(1.962)	(4.672)	(0.154)	(3.410)	(2.046)
L2.dln*MLPR*	-0.141	-0.894	1.895	-1.056	0.236	-1.302	-2.665
	(0.990)	(2.750)	(1.656)	(3.943)	(0.130)	(2.879)	(1.727)

TABLE 4 (continued)

Dependent/ Independent Variables	dln*LFPR*	dln*AVA*	dln*EDU*	dln*RISK*	dln*MLPR*	dln*MECH*	dln*RGDPC*
L.dln*MECH*	-0.253***	-0.095	0.070	-0.062	0.026**	0.010	-0.189
	(0.065)	(0.180)	(0.109)	(0.259)	(0.009)	(0.189)	(0.113)
L2.dln*MECH*	0.423***	-0.508	0.099	-0.652	0.019	-0. 012	-0.638***
	(0.093)	(0.257)	(0.155)	(0.369)	(0.012)	(0.269)	(0.161)
L.dln*RGDPC*	-0.069	-0.232	-0.399*	0.080	0.007	0.470	0.166
	(0.100)	(0.279)	(0.168)	(0.400)	(0.013)	(0.292)	(0.175)
L2.dln*RGDPC*	-0.105	0.087	0.123	-0.442	-0.024*	-0.172	0.166
	(0.085)	(0.236)	(0.142)	(0.339)	(0.011)	(0.248)	(0.148)
constant	-0.008	-0.013	0.090***	0.112*	-0.007***	0.067	0.095***
	(0.014)	(0.037)	(0.022)	(0.054)	(0.002)	(0.039)	(0.023)

Notes:

Standard errors in parentheses * p<0.05, ** p<0.01, *** p<0.001

We find that mechanisation of agriculture has a strong negative impact both on female labour force demand and supply in many ways. On the demand side, it replaces man power and animal power in the agriculture sector. The introduction of the tractor is always accompanied by other allied machinery. Most of the manual jobs, like weeding and winnowing, for females have disappeared from the agriculture sector. The dominance of men in using equipment (see for example Boserup, 1970) in agriculture forces females to withdraw from the labour force when mechanisation ensues. Our results show that female labour force participation rate declined by 28% (Table 4) due to mechanisation. It is evident that gender inequality in the society reduces employment

opportunities for women (Das and Desai, 2003). Mechanisation was also accompanied by the introduction of high yielding crop varieties, modern means of irrigation, pesticides and use of electric power for irrigation. These changes enhance the productivity of labour (particularly male labour force) and societal belief that females are less productive reduces the demand for female labour in the agriculture sector. Further, the agriculture sector in India has transformed from subsistence to commercial. Increased production of crops (grains) and commercialisation strengthen the economic position of households. Rising household income leads to less work or reduction in labour supply (income effect) particularly for females in the Indian society which constrains female labour force participation to preserve the social status of the family. The results from the VAR model for male labour force participation rate clearly indicate that mechanisation has a highly statistically significant positive effect on male labour participation rate and *MLPR* increases by 2%, consistent with the findings in other studies (e.g., Boserup, 1970).

Agriculture and its mechanisation are at the centre of our argument. We propose that changes in the agriculture sector have a dominant role in explaining the decline in the overall female labour force participation rate in India. We note that 67% of India's total population live in the rural areas where agriculture and its allied occupations (poultry farming, dairy farming) are the major economic activities. In India, urban female labour force participation rate has stagnated and remain very low (around 20%) since 1987 (Klasen and Pieters, 2015). On the other hand rural female labour force participation has declined from 52% in 1993 to 39.9% in 2010 (Neff et al. 2012). This implies that the overall decline in female labour force participation can be attributed largely to the decline in rural (agricultural) labour force participation. Further, jobs in urban areas, particularly in the fastest-growing service sector still could not generate

enough employment opportunities to absorb a growing working age population, hence labour force participation remain stagnant in urban areas as mentioned previously. As well, the service sector is dominated by transport, trade, IT and financial services, all of which require skills that majority of females do not have. From the total female working age population, 37.7% is illiterate, 8% has completed senior secondary and only 6.8 % has a bachelor degree or higher. It is even more shocking to see that only 0.04% of working age females has a technical certificate or diploma (Census of India, 2011). For this reason, among others, employment opportunities in the growing service sector and industry largely benefit men due to the gender gap in level and quality of education between males and females in India.

Aside from constraints from the demand side (e.g., male workers are preferred over females because males can use farm machinery and/or are more educated than females), there are also many constraints from the supply side. We argue that security risks contribute negatively to female labour force participation rate in India. Social norms and traditions make security risks a hindrance for females in entering the labour market. We incorporate number of rape cases reported in the VAR model and the results are statistically significant at the 5% level for the lagged security risk variable (*RISK*). The results show that security risks cause an 11% decline in the change (Table 4) in the female labour force participation rate. The proxy for security risks affects the female labour force participation at the second lag as expected because the victims and families try not to disclose these kinds of tragedies for the sake of maintaining their family's honour in the face of society. After some time, no secret can be kept hidden forever, they are eventually disclosed which then causes fears of security risks that discourages females from going out and/or being in contact with unfamiliar men in the labour market. Consistent with the findings of Sudarhsan and Bhattacharya (2009), we find

that security risk is a key reason why women prefer to work in the home or small cottage industries rather than in a factory as their families do not want them to have contact with unfamiliar men.

Labour force supply is also negatively affected by family decisions and household income. We include ratio of female to male secondary education (dln*EDU*) and male labour force participation rate (dln*MLPR*) to capture the effect of education stigma, social stigma and household effect on female labour force participation rate in India. Our results show that male labour force participation has a substantial large negative impact on female labour force participation rate but it is marginally statistically significant at the 10% level. The negative effect of education on female labour force participation rate is consistent with the literature. The inclusion of the ratio of female and male education allows us to capture multiple effects on female labour force participation rate. The rising ratio can be interpreted as a move of the female population away from the labour market towards gaining education which we refer to as the education effect. The ratio of female to male secondary education can also indicate gender inequality. Although the ratio has been rising over the sample period, female school enrolment remain far below that of male enrolment. Educated males are more likely to join the labour force. The VAR model for male labour force participation rate shows that education causes a 2% increase in male labour force participation rate (*MLPR*) which in turn increases the household head's income. Due to the (household) income effect, females tend to withdraw from the labour force. The results of this study are consistent with Neff et al. (2012) who find that rising household income lowers the female labour force participation rate. The family unit is a dominant and important institution in Indian Society. It is a tradition that women specialise in domestic duties. Families typically make labour market decisions for their members based on traditions

like this. Our results are consistent with the argument that male education, that leads to higher male (household) incomes and female labour participation rates are negatively correlated.

VII. CONCLUSIONS AND POLICY IMPLICATIONS

India has been experiencing rapid economic growth over several decades, yet female labour force still shows a declining trend over this rapid growth period. We explore the possible causes of this decline in labour force participation. Our results, suggest that both demand and supply side factors contribute to the decline in female labour force participation rate.

We find that mechanisation of agriculture causes a decline in the demand for female labour force, as males are preferred over females to work with farm machinery. Our findings also show the need for policy makers to review existing policies of gender equality and to examine how effective these policies are at the grassroots level. We find that the education level of females remain far below that of males to enable females to meet the labour market requirements for more skilled workers. What is required is for both quantity and quality of female education to be raised. There is a pressing need in India to revamp the formal education system which follows an outdated centuries old structure that does not essentially meet the labour market requirements. Formal education does not guarantee jobs in the labour market. Education providers should promote adult education for males and females that develops and enhances technical skills that match current labour market requirements, including for instance training in the use of farm machinery for agriculture. The reduction of inherent social restrictions in the society for females is also of utmost important for a country like India.

Policy makers should take advantage of information technology to educate females living in the remote areas and those whose mobility is restricted due to security risks to enable them to participate in the labour market. Strict enforcement of laws that secure the mobility and safety of females and ensure justice for victims can also help encourage females to join the labour force.

Our study also point toward the need for rural and urban development to occur simultaneously. Rural areas (particularly agriculture and its allied occupations) provide employment opportunities to a large portion of the population. Moreover, female participation rate is highest in agriculture among all the sectors. Modernisation of agriculture needs to progress in such a way that it can generate equal employment opportunities for females and males.

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