# Title: Labour force projections in India until 2060 and implications for the demographic dividend

**Guillaume Marois, c**orresponding author
Asian Demographic Research Institute, School of Sociology and Political Sciences, Shanghai University, 99 Shangda Rd., Shanghai, 200444, China,
International Institute for Applied Systems Analysis, Wittgenstein Centre for Demography and Global Human Capital (IIASA, OeAW, University of Vienna), Laxenburg, Austria
Contact: marois@iiasa.ac.at / +86 131 6201 6801

**Ekaterina Zhelenkova**
University of Vienna, Wittgenstein Centre for Demography and Global Human Capital (IIASA, OeAW, University of Vienna), Vienna, Austria
Contact: ekaterina.zhelenkova@univie.ac.at

**Balhasan Ali**
International Institute for Population Sciences, Mumbai, India
Contact: alihasancs92@gmail.com

# Labour force projections in India until 2060 and implications for the demographic dividend


## Abstract

While India is entering the period of demographic dividend, female labour participation rates remain very low. This paper aims to provide the very first labour force projections for India and its regions up to the year 2060. Projections are achieved using a discrete-time microsimulation model in which changes in population size and composition come from the interaction between demographic characteristics, educational attainment, and secular tendencies. Labour force participation rates are estimated at the individual level using personal characteristics as predictors. Three scenarios have been devised on future labour force participation: one assuming constant rates and the two others assuming different degrees of increase in female labour force participation. Results show that under constant labour force participation rates, the labour force dependency ratio (non-workers/workers) is very unlikely to attain favourable levels, which compromises the potential demographic dividend that the country could gain from its favourable age-structure. At the subnational level, the forecast yields the most favourable dependency ratio in 2060 in the regions that combine both a low-age dependency ratio and a higher participation of women. Results moreover suggest that female labour force participation is a better driver of the labour force dependency ratio than the age composition.



**Key words:** *Demographic dividend; Labour force participation, Gender inequalities, Projections, India*

## Introduction

India is about to enter the final stage of its demographic transition. In the past few decades, its fertility level has declined sharply and continuously from more than 5 children per woman in the 1970's to 2.2 nowadays, and is expected to fall below the replacement level of 2.1 within the next decade (United Nations, 2019b). Consequently, the share of the working-age population, which has typically produced more than it has consumed is growing. At the same time, the share of children is declining and the share comprising the elderly remains low. The relationship of these economic life cycles with this shift in the age structure is likely to provide more labour supply and more saving and investment in education, which should give India a demographic dividend characterised by quick economic development (Ladusingh & Narayana, 2012; Mason, 2005). From a demographic point of view, this mechanism is captured by the demographic dependency ratio (or age dependency ratio, ADR), which includes the non-working age groups (children and the elderly population) in the numerator and the working-age population in the denominator (typically the 15-64 year-olds), or alternatively, by its inverse equivalent, the support ratio, dividing the working-age group by the non-working-age group (Bloom et al., 2007; Bloom & Williamson, 1998).

However, this purely demographic approach is incomplete. Indeed, the demographic dividend needs favourable institutions and labour market factors to translate the addition of working-age adults in the population into an effective economic asset (Golley & Tyers, 2012). An improvement in education could even come to take centre stage within the shift in age structure as has been seen in the patterns of economic growth in countries completing their fertility transition (Crespo Cuaresma et al., 2014; Lutz et al., 2019). This notwithstanding, an improvement in education alone can barely be sufficient when not accompanied by a favourable age structure (Kotschy et al., 2020). In any case, it becomes increasingly clearer that assessing the demographic dividend of a region should go beyond its age structure (Golley & Tyers, 2012). This is because, firstly, not all people making up the working-age population are involved in factual work. Secondly, not all workers are equally productive. Those who are educated are much more likely to have formal jobs with higher incomes that allow for more savings and investments (Lutz & KC, 2011; Mitra, 2016).

While most population projections for developing countries only focus on the age structure, the Wittgenstein Centre has, in the last decade, implemented the human capital dimension in its global projections (Lutz et al., 2014, 2018). This approach has since been reproduced for India at the subnational level specifically (KC et al., 2018), but none of these projections went as far as to include  the labour force participation dimension.

The main objective of the present paper is to provide the very first labour force projections for India and its regions up to the year 2060. The focus has been placed particularly on India because, firstly, it is soon to be the most populous country in the world and its development will have a preponderant impact on the future of humanity. Secondly, because it is a model country entering the demographic dividend period and seeing improvement in education, all while having very low female labour participation rates (about three times lower than men) (Verick, 2018). Assessing the potential demographic dividend through the labour force dependency ratio (non-workers/workers) rather than the age dependency ratio is thus likely to yield a different and more accurate outcome on the demographic and economic challenges that the country is going to face. Due to this stark gender inequality in the labour market and seeing as women's inclusion in the labour force is an important driver of development (Verick, 2018) as well as a critical factor in fulfilling the no. 5 UN Sustainable Development Goal for gender equality and empowering women(United Nations, 2016), the second objective of this paper is to assess the consequences of policy-oriented scenarios testing the impact of higher female labour force participation and its implications on the potential demographic dividend.

Hitherto, the only existing subnational human capital projection for India has relied on a multistate cohort-component approach (KC et al., 2018). We have built our projection model from the latter by transforming it into a microsimulation framework, which allows for higher flexibility in the inclusion of additional dimensions (such as labour force participation) and its interaction with characteristics of other individuals, such as education and fertility behaviour.

## Female labour force participation in a transforming society

India's unusual course of high growth and declining female labour force participation (FLFP) has been receiving heightened attention in academic circles and beyond. Numerous studies have pointed out that despite the drop in fertility rates, rising female education levels and higher incomes, there has been no substantial increase in women's employment rates, which further limits the much-anticipated benefits of India's demographic dividend (Desai, 2010; Mehrotra, 2015; Navaneetham & Dharmalingam, 2012). It has been determined that this complex phenomenon is caused by both demand- and supply-side factors.

Although the sluggish performance of FLFP in the Indian labour market can be observed in both urban and rural settings, the figures for metropolitan areas can be identified as more or less stagnant, whereas the numbers for rural areas are falling dramatically (Abraham, 2019; Das, 2011). India has traditionally been largely dependent on its agricultural sector, which absorbs a significant proportion of its labour force, notably in rural areas. At the same time, the agrarian sector is known to engage the least-educated groups of people (Aggarwal & Kumar, 2015). However, as economic change progresses and the focus shifts away from agriculture, the demand for agricultural workers and, by extension, work opportunities in this previously crammed sector, decrease. As noted by Klasen and Pieters (2015), changes in the sectoral structure of employment are directly responsible for the decline in the volume of FLFP as the agricultural segment, which has traditionally employed more women, is on course for rapid optimisation. They further highlight that the sectors that attract female workers have also been seeing the least expansion (Klasen & Pieters, 2015), which means that the scope of opportunities for women is being de-escalated and structurally curbed. It is important to consider that India has experienced an atypical structural shift from agrarian to service economy, to a large extent 'leapfrogging the manufacturing sector' (Mitchell & Ashley, 2009). As emphasised by Lahoti and Swaminathan (2016), the impetus for growth is to be found in the service sector, which normally requires a set of high-level skills – a pre-requisite that disqualifies most women from applying for those jobs as they simply do not possess the necessary skillset. And even if more industrial agendas[1] for expanding the manufacturing segment were to enter the public debate, workers would still need to be more educated in order to be able to operate new equipment or to meet the specific job requirements.

The fact remains that education is a multidimensional variable which offers insights not only into demand-side incentives, but also supply-side incentives. Much of the research on female education in India (Chatterjee et al., 2018; Chaudhary & Verick, 2014) describes the relationship between FLFP and education as one that is U-shaped. Thus, participation rates are comparatively higher for illiterate or the least-educated women, who, by necessity, usually work in farms and fields, have limited employment options and are poorer (Verick, 2018). However, as women move up the educational ladder, they are likely to leave this type of employment. Goldin (1994) extends

[1] The infirmness of the manufacturing segment and its impact on employment have been widely addressed in the literature (Colmer, 2016; Iyer, 2018; Kathuria & Natarajan, 2013) and by policymakers. The leap towards service economy has left the manufacturing segment disproportionately unattended, which has prompted the government to propose such national initiatives as 'Make in India'. Its goal is to accommodate India's demographic dividend by creating millions of new jobs in manufacturing as well as to smoothen the economic transition. This could potentially significantly stimulate FLFP as it did in India's neighbouring Bangladesh and Sri Lanka.

the argument by considering the emergence of a white-collar sector, implying that there access to this kind of employment is only limited to the most educated group. This leads to a situation where education and demand for white-collar work among both men and women increase, and the fierce competition may crowd out female workers due to the paucity of such jobs on the labour market (Datta Gupta et al., 2020). At the same time, the association with the increasing revenues, or the income-effect, must be considered. As the education of men also rises significantly, this allows for greater household income and benefits. It has been extensively debated that FLFP also shows a U-shaped relationship with economic development. Gunatilaka (2013) states that as incomes increase and the necessity for an additional salary reduces, households can 'afford' to withdraw women from the workforce. Mammen and Paxon (2000) assert that women will also try to avoid other than white-collar work since it cannot compensate for the fixed costs of their time away from home. Their research further suggests that once women acquire higher education and achieve necessary qualifications to compete in the white-collar sector, they are less likely to refrain from joining the workforce (Mammen & Paxson, 2000). Although it has been argued that the phenomenon is a standard trend of economic development (Boserup, 1970) and that with the progress of development women's employment can catch up (Tam, 2011), the extent of such prospects for the particular case of India has been called into question. Gender disparity, which still prevails in the form of socially-constructed and predefined gender roles, is more than likely to significantly affect India's labour market picture (Batra & Reio, 2016).

The argument whereby patriarchal inclinations act as a deterrent to female labour inclusion in Indian society finds strong support in scholarly literature (Rawat, 2014; Tisdell, 2000). It is in the household that the traditional role of a woman is perceived as being the most valuable (Datta Gupta et al., 2020), meaning that familial responsibilities eclipse other potential pursuits such as professional activity (Fletcher et al., 2018). Women are viewed predominantly as caregivers and are expected to focus on the bearing and rearing of children and on keeping house. Furthermore, the sociological discourse urges to take account of the practices of arranged marriage and dowry, and of their association with a family's social status (Desai & Andrist, 2010). Lahoti and Swaminathan (2016) argue that the fact of a woman being employed could suggest that her family is under significant financial strain, which means families may ban their women from undertaking professional work in an attempt to keep up appearances and a good reputation as 'a family of means'. Therefore, seeing as female nonparticipation in the labour market is associated with the higher status of her family and especially with that of her husband (Datta Gupta et al., 2020), it is only to be expected that women will be caught up in a dilemma between working and preserving the status. All this creates additional barriers for women to even enter the labour market in the first place.

## Other labour force projections

Although demographic projections including those on the labour force participation are not common, many other models exist, mainly for developed nations. The most customary and straightforward method is to apply predetermined participation rates by age and sex to standard demographic projection outputs.

Those rates are established a priori using a variety of methods. One normally used entails keeping the rates by age and sex recently observed constant (Loichinger, 2015; Loichinger & Marois, 2018). The total participation rate of the country would then only depend on the change in the age and sex structure of the population. This type of assumption can, however, prove inconsistent where there are significant changes in trends among cohorts. For that situation, the cohort development approach might be more appropriate (European Commission, 2015; Marois et al., 2019). In the latter, future sex- and age-specific rates are calculated by applying exit and entry rates to initial labour force participation rates. Finally, as projections do not necessarily aim at predicting, some benchmark assumptions can be used – such that are based on an objective to achieve (e.g. gender equality in labour force participation) (Loichinger, 2015; Marois et al., 2020). Those scenarios could inform policies by bringing to the fore the potential impact that changes in labour force participation may have on the future workforce. They could, moreover, be of service to a sensitivity analysis of the assumptions concerning labour force participation.

For Europe, the labour force projection of the Aging Report (European Commission, 2015) has given particular attention to the increase in labour force participation of women and, therefore, formulated its assumptions with the use of the cohort-development approach. In the European context, Loichinger (2015) uses a multistate demographic model by age, sex, education and country to specifically address how the increase in educational attainment that is likely to occur can impact the size of future labour force. Marois et al. (2020) later converted the model into a microsimulation framework in order to take into account more sources of heterogeneity in the modelling of labour force participation, such as the place of birth, the age at the time of immigration and the duration of stay. They modelled labour force participation rates from regression parameters based on individual characteristics, which also allows to take into account cohort-specific behaviours. Microsimulation models using a similar approach have been built for Canada and the United States (Bélanger et al., 2019; Van Hook et al., 2020), while different variants of overlaying participation rates by age and sex (and sometime education) on outputs of multistate or cohort-component models have been made in other developed regions (Cheng & Loichinger, 2017; Peacock & Finlayson, 2009; Toossi, 2006).

In all the cases, the inclusion of labour force participation in demographic projections has proven relevant, as it has allowed to have a more accurate outlook on future population challenges. For instance, it has shown less daunting consequences of population aging as labour force might decrease slower than the working age population in aging countries as a result of increasing labour force participation in women (European Commission, 2015), or as an effect of increasing both participation rates and productivity (Loichinger, 2015; Marois et al., 2020).

In addition, according to our current knowledge, as far as economically developed countries are concerned, no labour force projection models have as of yet been conceived for developing regions in the world. The labour force projection provided in this paper is thus the first of this kind not only for India, but also for other developing countries.

## Definition of concepts

### Working age and labour force

The working-age population usually includes the population that is more likely to work based on their age. Although far from being etched in stone, most definitions set the minimum age threshold at 15 and the maximum at 65, which corresponds roughly to the age at which people start entering the labour market and the age at which people take their retirement, respectively.

According to the International Labour Organisation, the labour force 'comprises all persons of working age who furnish the supply of labour for the production of goods and services during a specified time-reference period' (International Labour Organization, 2019). The labour force thus refers to the employed population and to those people who are unemployed but who are actively seeking employment. Assessing labour force participation in poorer countries is challenging, as this traditional definition of the labour force underestimates the participation of those who work at home or in the informal sector, with women overrepresented in both these groups (Hirway & Jose, 2011; Verick, 2018).

The Periodic Labour Force Survey (2017/18) of India that is used in this paper to estimate labour force participation helps to capture this type of workers in the numerator (National Statistical Office, 2019). In addition to salaried employees, the labour force also includes the self-employed in household enterprises (including own-account workers, employers, and helpers) as well as casual labour. Helpers in household enterprises are those who gratuitously assist a person living in the same household in running the household enterprise. Casual workers, for their part, do not have a regular job, but are engaged only casually and receive wages as per a daily or periodic work contract. This category comprises notably those who work under the Mahatma Gandhi National Rural Employment Guarantee Act, which seeks to offer 100 days of work to poor people in rural areas. Finally, the labour force includes both those who are working and available to work for a large part of the year (principal status) and those who have worked for 30 days over the course of the year (subsidiary status).

Despite those efforts, a certain underestimate of economic activity is likely to remain, in particular for women, as informal employment might not be measured correctly because of the difficulty in distinguishing between informal jobs and household tasks (Hirway & Jose, 2011). Indeed, female participation rates come out as significantly higher when they are estimated on the basis of the women's factual daily schedules as opposed to when purely interrogative surveys are used to determine those women's hard-and-fast status as employed or in search of employment (Hirway & Jose, 2011). Moreover, the definition of the labour force used in this study is not broad enough as to cover the quality of employment and underemployment, both of which are crucial in the context of the large gender pay gap and the high segmentation of the job market based on gender. In other words, the contribution of women in the labour force may still not be optimal if they occupy less productive jobs (Verick, 2018).

Nevertheless, for the purpose of our study, the labour force as estimated by Periodic Labour Force Survey (2017/2018) remains the best available definition as it more or less matches the standard definition used internationally, and because it provides information about a large sample of population in all the states of India, and because it is accurate for the most productive workers (those with formal jobs).

### Dependency ratios

The decline in fertility leads to a lower proportion of children and a higher proportion of people in the working age group. This generally means fewer people in a situation of economic dependency and, entails the bringing of the demographic dividend to a country. The conventional **age dependency ratio** (ADR) is widely used to measure this dynamic. For a region *r* at time *t*, the ADR is the ratio between the children and the elderly (0-14 + 65 and older) to the traditionally working-age groups (15-64) (equation 1). This indicator strictly reflects the age structure of the population.

Eq. 1 $$\mathrm{ADR}_r^t = \frac{Pop0{-}14_r^t + Pop\ 65over_r^t}{Pop15{-}64_r^t}$$

Although the age of a population is a major determinant of the economic burden, not every person in the working age population works as a matter of fact. In other words, the ADR reflects the burden on potential workers as opposed to factual ones.

As examined in the literature review, most women of working age in India are not workers, and the demographic dividend expected from the decline in fertility might not be optimised. A more accurate indicator of the economic burden of a region would be the labour force dependency ratio which includes all economically inactive persons (I) in the numerator and the active ones (A) in the denominator (equation 2), regardless of their age. It thus captures the fact that an important share of people aged 15-64 are not in the labour force (e.g. students, housewives, early retirees).

Eq. 2 $$\mathrm{LFDR}_r^t = \frac{I_r^t}{A_r^t}$$

## Projection method

The projection model developed for this paper uses a microsimulation approach (Van Imhoff & Post, 1998). A microsimulation model starts from a baseline population that consists of individual actors whose characteristics represent the composition of a given population across chosen dimensions. These individual actors are exposed to the risk of a set of events relevant to their state and specific to their own characteristics – death, births of a child (which generates a new actor inside the model), moving to a different region in a country, leaving the country, achieving the next level of education, entering or exiting the labour market, and so on. Transitions between the particular states are determined stochastically with a random experiment (the Monte Carlo method). Microsimulation thus allows to not only include a larger set of dimensions than the standard multistate population projection models, but also to easily handle competing risks.

Microsimulation methods are particularly useful when heterogeneity is of significance in the projection modelling or in the projection outcomes (Spielauer, 2010). A multistate cohort-component method can only handle a limited number of dimensions, because the number of cells for the transition matrices corresponds to the multiplication of the number of categories of each dimensions. In microsimulation, each additional dimension only adds one new column in the dataset. Furthermore, microsimulation can more easily model events for which behaviours can be better understood at the micro–level than at the aggregated level. For instance, having had a child in the past few years could be a major predictor for female labour force participation. At the micro-level, this predictor can easily be taken into account as it only requires to add one column recording the time since the last birth occurred and what value is incremented every year, without any complex modelling. The variable can then be used in the modelling of other events, using for instance relative risks or logit regression parameters.

## Properties of the microsimulation model INDIMIC

The model built for this paper is called INDIMIC. It projects the population of India by ages (5-year age groups), sex, region, education, type of residence (urban/rural) and labour force participation status. It is built with the Statistical Analysis System (SAS) and has the following proprieties:

- *Time-based*. It simulates the life of all individuals from time *t* to *t*+*a*, then repeats from *t*+*a* to *t*+2**a* and so on up to the end of the time span.
- *Discrete time*. The model only considers the population at specific points in time (by 5-year steps), without considering what could be happening between those points.
- *Stochastic*. All events are modelled stochastically using random experiments (the Monte Carlo approach), which involves comparing probability with a random linear number from 0 to 1 in order to determine whether or not the event occurs.

For the purposes of this paper, INDIMIC is built in three steps:

1. The replication of a projection by state and education from a multistate cohort-component model (KC et al., 2018) into a microsimulation framework. This allows to use already validated long-term assumptions for the demographic and education components of the projection instead of having to build them from scratch.

2. The adjustment of the base population and calibration on the most recent estimates of the United Nations World Population Prospect (United Nations, 2019b) for the period 2010-2020. The replicated projection starts in 2010, and some new estimates are now available. Implementing them allows to have a more accurate starting point for the projection.
3. The implementation of a labour force participation module taking into account age, education, region, fertility and the relationship between them. This part is the main innovative outcome of INDIMIC, as labour force has never before been projected for India.

### *1. Replication of the multistate cohort-component projection*

*The base population*

Any microsimulation model for demographic projection requires a comprehensive microdata set representing the starting population. We have built our base population from scratch, using the aggregated population by age, sex, region, type of residence, and education in 2010 from KC et al. (2018). It includes 35 states (including union territories) of India as per the geographical divisions from the 2011 census all classified as either rural or urban areas, which in total makes it 70 'regions'. Educational attainment contains 6 categories (e1-e6): 'No education', 'Incomplete primary', 'Complete primary', 'Lower secondary', 'Upper secondary', and 'Postsecondary'. The definition of variables and their categories is detailed in SI.

For each subgroup of population, the sample size of the base population represents 0.05% of the population size when that size is higher than 10,000. For groups with smaller populations, using the same sample rule might generate too few individuals, which would lead to less accurate forecasting results by increasing the Monte Carlo error. At the same time, the dataset would be too loaded if we were to include too many observations for groups that are very marginal (such as women aged 90 to 94 who have postsecondary education and live in a rural area of Dadra & Nagar Haveli). We have thus decided that, for our purposes, the number of observations should decrease when the size of the population in the group shrinks: 40 cases for populations between 1,000 and 10,000, 30 cases for populations between 100 and 1,000, 10 for populations between 30 and 100 and 2 for populations lower than 30. The resulting dataset has 846,024 cases with an average population weight of 1,431.2 (S.D.=890.5).

*Demographic and education components*

The demographic and education modules of INDIMIC are based on assumptions sourced from the baseline scenario of the multistate model developed by KC et al (2018). Educational attainment matters for fertility and mortality, but not for migration. Before the threshold age of 15, the education of the mother is used for determining mortality rates. Internal mobility is modelled on the age- and sex-specific origin-destination matrix. In addition to internal mobility, the model allows for the reclassification of rural areas as urban. The model is closed, which means there is no international migration.

In this multistate projection, events are ordered as follows:

1. Mortality is applied with survival ratios by age, sex, education and region;
2. Education transition rates by age, sex, region and education are subsequently applied;
3. For those who survive, the domestic migration is then applied using age- and sex-specific rates from an origin destination matrix;
4. Births are generated with fertility rates by age, education, and region applied to the exposed population;

5. Finally, region-specific reclassification rates from rural to urban areas are applied.

The assumptions have been formulated according to past trends, expert judgments, and statistical modelling, a summary of which is displayed in Table 1. Their detailed methodology is available in the supplementary information in KC et al. (2018).

**Table 1. Summary of assumptions for demographic components and education**

| | | Period | India | Highest region | Lowest region | Rural | Urban | No education | Post-secondary |
|---|---|---|---|---|---|---|---|---|---|
| **Total fertility rate** | | **2010-2015** | **2.4** | **3.4 (BR)** | **1.4 (MN)** | **2.7** | **1.9** | **3.3** | **1.6** |
| | | **2055-2060** | **1.8** | **1.9 (CT)** | **1.2 (TR)** | **1.8** | **1.6** | **2** | **1.5** |
| **Life expectancy** | **Male** | **2010-2015** | **67.2** | **76.3 (CH)** | **62.0 (AS)** | **65.1** | **71.1** | **63.2** | **76.2** |
| | | **2055-2060** | **79.0** | **88.2 (DL)** | **74.7 (CT)** | **77.0** | **81.3** | **74.2** | **84.8** |
| | **Female** | **2010-2015** | **70.2** | **81.7 (CH)** | **64.9 (UP)** | **67.9** | **75.2** | **66.6** | **81.5** |
| | | **2055-2060** | **84.8** | **94.9 (CH)** | **80.6 (CT)** | **83.1** | **86.8** | **80.0** | **90.7** |
| **Sex ratio at birth** | | **2010-2060** | **1.07** | **1.13 (JK)** | **Many=1.04** | **-** | **-** | **-** | **-** |
| **%no education at 30-34** | **Male** | **2010** | **22.6%** | **36.7% (BR)** | **6.1% (LD)** | **27.0%** | **14.6%** | **-** | **-** |
| | | **2060** | **1.4%** | **2.0% (PB)** | **Many<1%** | **1.2%** | **1.7%** | **-** | **-** |
| | **Female** | **2010** | **41.3%** | **61.4% (RJ)** | **7.5% (KL)** | **50.5%** | **23.4%** | **-** | **-** |
| | | **2060** | **0.6%** | **All <1%** | | **0.5%** | **0.8%** | **-** | **-** |
| **%postsecondary at 30-34** | **Male** | **2010** | **15.1%** | **31.4% (PY)** | **8.3% (TR)** | **9.0%** | **26.3%** | **-** | **-** |
| | | **2060** | **27.6%** | **46.1% (PY)** | **16.1% (AS)** | **24.0%** | **31.6%** | **-** | **-** |
| | **Female** | **2010** | **10.1%** | **31.9% (CH)** | **3.3% (BR)** | **3.9%** | **22.1%** | **-** | **-** |
| | | **2060** | **30.2%** | **42.3% (PY)** | **17.7% (BR)** | **26.4%** | **35.4%** | **-** | **-** |
| **%Urban** | | **2010** | **31.1%** | **97.5% (DL)** | **10.0% (HP)** | **-** | **-** | **-** | **-** |
| | | **2060** | **46.8%** | **99.5% (DL)** | **14.3% (BR)** | **-** | **-** | **-** | **-** |
| **Total 5-year out-migration rate** | | **2010-2015** | **5.4%** | **15.4% (LD)** | **31.2% (LD)** | **5.9%** | **4.2%** | **-** | **-** |
| | | **2055-2060** | **5.8%** | **1.7% (ML)** | **2.3% (MN)** | **5.1%** | **6.6%** | **-** | **-** |
| **Total 5-year o in-migration rate** | | **2010-2015** | **5.4%** | **22.0% (LD)** | **1.8% (MN)** | **4.8%** | **6.6%** | **-** | **-** |
| | | **2055-2060** | **5.8%** | **37.6% (LD)** | **1.6% (MN)** | **5.2%** | **6.6%** | **-** | **-** |

Source: KC et al. (2018). Compilation by authors.

In short, fertility in the whole country is projected to decrease from roughly 2.4 children per woman in 2010 to 1.8 in 2060, although with large heterogeneity among regions (between 1.2 and 1.9 in 2060) and between educational groups (between 1.2 for women with postsecondary education to 2.0 for women with no education in 2060). Trends in life expectancy are based on the UN World Population Prospect 2015, in addition to which differentials by education, region and type of residence have been applied. The value for the whole country is assumed to pass from 68 years for 2010-2014 to 77 years for 2055-2060.

Assumptions for the future are based on the extrapolation of past trends in the educational attainment progression ratios (i.e. the proportion of those who completed the next level of educational attainment among those at the current level). By 2060, almost everyone in the younger cohorts with a completed education pathway will have had at least basic education. In the 30-34 age group, the proportion with postsecondary education is projected to progress from 15.1% in 2010 to 27.6% in 2060 for men and from 10.1% to 30.2% for women, again with a large heterogeneity among regions. Age- and sex-specific migration rates are assumed to remain constant with what has been observed in the last census. The reclassification rates of rural regions as urban which occur as a result of urbanisation are region-specific and are assumed to follow the logit trend. For the whole country, the proportion of people living in an urban area should pass from 31.1% in 2010 (ranging from 10.0% to 97.5% between regions) to 46.8% in 2060 (ranging from 14.3% to 99.5%).

INDIMIC accurately replicates the multistate model into a microsimulation framework. The complete validation can be consulted in SI, section X.

### *2. Adjustment and calibration for recent demographic estimates*

The base population from KC et al. (2018) was based on the last available census from 2011 (with a backward interpolation of 1 year), without adjustments to correct for under- or over-reporting. Furthermore, almost 10 years have passed since that time, and new estimates of demographic components can now be accounted for. Three calibration steps have been taken to arrive at the most up-to-date base population in our projection.

1. The base population in 2010 is calibrated on the UN World Population Prospect's estimates by age and sex for 2010 for the whole country. These estimates correct for the under- and over-reporting in the census.
2. Fertility and mortality rates from between 2010 to 2020 are then adjusted so as to give about the same number of births and deaths at the country level as what was estimated for 2010-2015 and 2015-2020 by the UN World Population Prospect.
3. The resulting population of 2020 is finally calibrated on the UN World Population Prospect's estimates by age and sex for 2020 for the whole country. These estimates are calculated from short terms projections based on most up-to-date estimates of population growth (United Nations, 2019a).

Because of this adjustment in the base population, the projected population in our paper differs slightly from what was published in KC et al. (2018), in spite of the same demographic assumptions being used (see figure 1 in SI). The overall population trends are, however, similar, with a sharp increase in population between 2020 and 2060 from 1.3G to almost 1.8G (in our projection) compared to 1.7 in KC et al. (2018) and 1.65 as per the UN WPP 2019. Our projection leads to determining a higher population to that in KC et al. (2018) because of the age- and sex-specific adjustment in the base population. Indeed, although the total population size for the whole country is roughly the same, there is some under-reporting in KC et al. (2018) for younger age groups (in particular the 0-4) and over-reporting for older ones (see SI Figure S4). The source of the faster population growth in KC et al. (2018) and our projection compared to the UN WPP 2019 comes from the inclusion of more sources of heterogeneity in the fertility rates: the share of regions with higher fertility indeed increases slightly throughout the projection as a result of an increase in births, thus increasing the fertility for the whole country (KC et al., 2018).

## *3. Implementation of the labour force participation module*

The labour force participation module is implemented at the end of each period, once the demographic events have reached completion. The labour force participation is itself calculated from logit regression parameters based on data from the Periodic Labour Force Survey 2017/2018 (population aged 15 to 74; n=323,092). At the end of each period, the module stochastically determines the labour force participation status, employing a Monte Carlo experiment and using personal characteristics as determinants. Predictors include age, sex, education, and a binary variable stating whether the individual is a woman that gave birth within the last 5 years. Therefore, assumptions in fertility have an impact on the labour force outcome.

Equation 3 below describes the model of labour force participation (P):

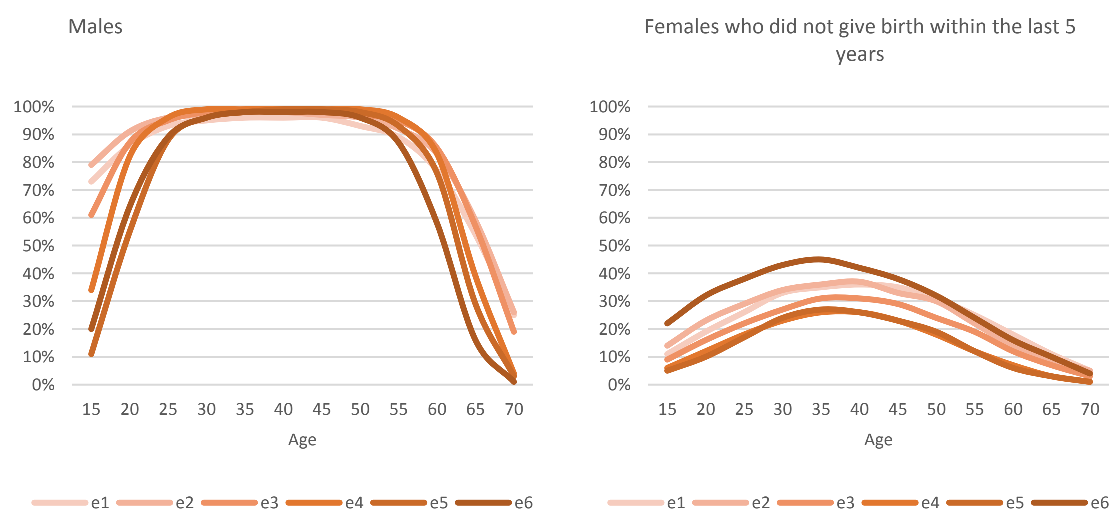
Eq. 3

$$\text{logit}(P) = \beta_{s,0} + \beta_{s,1}AGEGR + \beta_{s,2}AGEGR^2 + \beta_{s,3}EDU + \beta_{s,4}REGION + \beta_{s=F,5}YOUNG\_KID + \beta_{s=F,6}POSTSEC * YOUNG\_KID + \beta_{s,7}EDU * AGEGR + \beta_{s,8}EDU * AGEGR^2$$

Each sex (s) has their own set of parameters and own intercept. The slope for age, education, and having a young child is thus assumed to be the same in all regions. The variable REGION in the model combines the state and the type of residence (rural/urban). It has not been possible to have region-specific parameters because of the small number of respondents in many categories (such as highly educated people of specific ages in smaller regions). Region-specific parameters, however, allow regions to have a gradient of their own.

The max-rescaled R-Square is 0.534 for the males' model (c-statistic=0.912) and 0.237 for the females' one (c-statistic=0.766). Complete parameters can be found in the SI table S2. In figure 1, we show the predicted rates from the model by age and education for both males and females (who did not give birth within the last 5 years). In males, rates are very high for everyone from 25 to 59 years of age; the education gap concerns mainly young and older adults, with lower rates for higher-educated ones. In other words, highly educated men enter the labour market later because they stay in school longer, and they also retire earlier, perhaps because they may be able to afford it by virtue of having had better jobs during their working years. In females, for their part, the pattern is very different. For all education categories and in all age groups, rates are 2 to 3 times lower compared to men. Furthermore, as has been observed in other studies (Chatterjee et al., 2018; Chaudhary & Verick, 2014) the effect of education takes on a U-shape, with higher rates for both the highest and lowest categories.

**Figure 1 - Predicted labour force participation rates from Eq.1 by age and education, India**




The parameter for the binary variable YOUNG_KID accounts for a lower propensity to work among women who gave birth within the last 5 years. This parameter only affects women, since for men the decision to have a child does not impact their propensity to work (Gallaway & Bernasek, 2002). This parameter (-0.324) would thus reduce by about 8.5 percentage points a participation rate that would otherwise have been 42%. The negative impact of having a young child is, moreover, much larger for women with postsecondary education than for other women (-0.324+-0.390). Finally, parameters show a strong heterogeneity among regions, and also higher participation rates in rural areas than in urban areas of the same region. Parameters thus range from -2.124 (NCT of Delhi, rural area) to 1.830 (Chhattisgarh, rural area) for women and from -1.926 (Lakshadweep, urban area) to 2.533 (Daman & Diu, urban area) for men.

Because of the availability of data used in the statistical model, this module does not take into account the past labour force participation of individuals. In other words, what is modelled is the probability of being in the labour force rather than the probability of entering and leaving the labour market. In consequence, the modelling can project reliable cross-sectional values, but does not allow longitudinal analysis as lives might well be inconsistent in how they play out.

## Definition of scenarios

In this paper, three scenarios have been built regarding the future labour force:

1. The Constant Rates Scenario, which assumes no change in labour force parameters. It is the ‘business-as-usual’ scenario for which no major changes happen in labour force trends. At an aggregated level, labour force participation rates might however evolve from changes in population composition (such as higher education).
2. The BestRegion Scenario, which assumes that by 2060 the participation rates of women will reach at least the ones observed in Goa in the Periodic Labour Force Survey 2017/2018. In concrete terms, in the case of the regions that have lower parameters than Goa in Equation 1., those parameters are interpolated between 2020 (using the initial value of the regression) and 2060 (using the parameter for Goa, with the urban and rural ones treated separately from each other). Goa is picked as the ‘model’ region as it is one of the most developed in India, with a relatively high labour force participation of women, a sizable population in both rural and urban areas and a high human development index

(Permanyer & Smits, 2020). Indeed, the labour force participation of working-age women is about 33% in Goa as compared to 21% in all of India, while its Human Development Index (HDI) as of 2018 was 0.761 (0.647 for the national average). Other regions with higher participation rates for women either lack higher socioeconomic development (for example, Chhattisgarh, despite having 49% of working-age women in the labour force, has a HDI of 0.613) or do not have a significant population (women's labour force participation rate is 42% in Sikkim, but its population is only 0.6M). In other words, this scenario shows a realistic and moderate development pathway in terms of the participation of women for regions that lag behind.

3. The Equality Scenario, which assumes that labour force participation rates of women will gradually increase and by 2060 reach those which are true for men. This scenario is implemented by interpolating parameters between 2020 (using women parameters from equation 1) and 2060 (using the parameters for men). It shows what impact a strong and efficient policy aiming at reducing gender inequalities and empowering women would have on the labour force. Although unlikely to happen, this scenario is nevertheless not completely unrealistic, as gender equality in labour force participation has already been reached in some countries such as Sweden (Marois et al., 2020). In other words, this scenario shows the maximum plausible gain from an increase in the labour force participation of women.

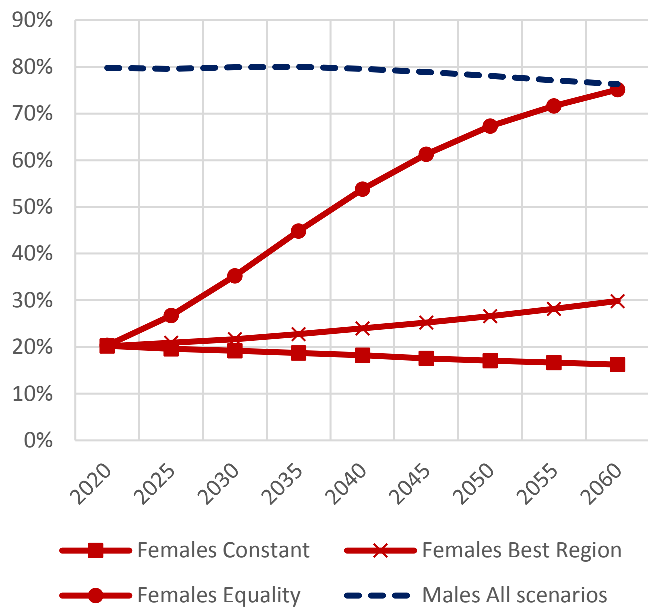
As a reminder, all these scenarios share the same assumptions as far as the demographic and education-related components of the projection are concerned. Therefore, their outcomes differ only in terms of labour force composition, while the population sizes by age/sex/education/region are roughly identical.

## Projected labour force participation rates

Labour force participation rates are, at an aggregated level, an outcome of the projection, as the inputs constitute parameters from logit regression used to calculate the rate at the individual level from a set of characteristics (age, sex, education, etc.). In the case of the Constant Rates Scenario, changes in the participation rate at the national level happen as a result of the change in the characteristics of the population over time. Figure 2 illustrates the ensuing labour force participation rate by gender among the population aged 15-74. For men (all scenarios), the rate is projected to be more or less stable, though with a slight decrease from 80% in 2020 to 76% in 2060, resulting from the expansion in postsecondary education which will mean delayed entry into the labour market.

As for women, when keeping parameters constant throughout the projection (Constant Rates Scenario), the rate also declines from 20% in 2020 to only 16% in 2060, which is in large part explained by the fast urbanisation of the country since women tend to work less in cities than in rural areas. The alternative scenarios yield very different outcomes. By 2060, the rate is 50% higher in the BestRegion Scenario and is multiplied by almost 4 in the Equality Scenario, reaching 30% and 76% respectively. In SI Figure S5, the evolution of projected rates is disaggregated by age.

**Figure 2. Projected labour force participation rate among the 15-74 year-old population by sex and scenarios, 2020-2060**

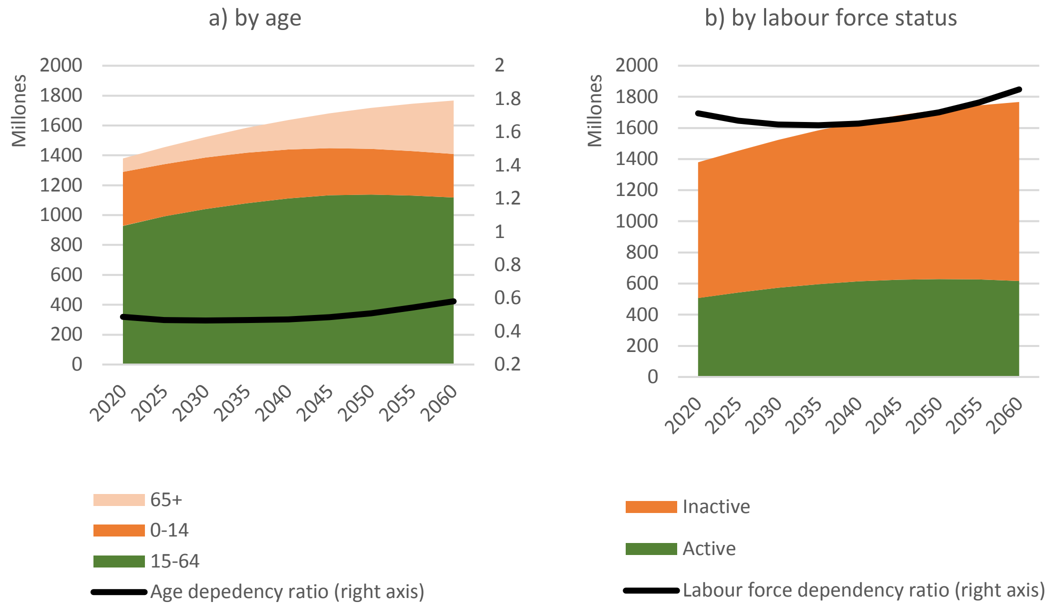



# Results

## The future labour force under current trends

First, we have examined the outcome of the Constant Rates Scenario, which is the one projecting the labour force with the 'business-as-usual' assumption. That is to say that this scenario shows what the future would be if current demographic trends were to continue and current participation rates by age, sex, education and region did not change. In figure 3, we show the projection outcomes by (a) age and by (b) labour force status for India for the time span between 2020 and 2060 as well as their corresponding dependency ratios.

**Figure 3. Projected population by (a) age and (b) labour force status, Constant Rates Scenario, India, 2020-2060**




The total population will increase by just over 25% from 2020 to 2060 (from 1.38G to 1,77G). The increase in the total population will at first happen mainly among its working-age segments to then make a gradual shift to the elderly population, which is anticipated to multiply by 4 between 2020 and 2060. Consequently, the age dependency ratio (ADR) will for many years remain close to 0.5, a level similar to what was observed in Western Europe from the mid-80's to the mid-00's, before starting to slowly increase in 2050, finally reaching 0.6 in 2060, as the country will face a population aging resulting from the last stages of the demographic transition. While the process is underway, India could benefit from a demographic dividend for most of this period. In comparison, this ratio exceeds 0.9 in countries less advanced in their demographic transition such as Niger or Mali, and 0.6 in countries facing population aging such as Japan or Finland (United Nations, 2019b).

However, when looking at the projection outcomes by labour force status, the situation is not as favourable. Indeed, the labour force dependency ratio (LFDR) is much higher than the age dependency ratio (ADR) in 2020 (1.7 vs 0.5). In other words, when looking at this more accurate indicator of economic burden, the number of non-workers is 70% higher than then number of workers, while the ADR shows much higher numbers of people in the working-age group than outside it. As explained before, this is because a large part of the potential workers (the working-age population), in particular women, do not participate actively in the labour market.

In the future, about 63% of the expected population growth will be among the inactive population, which will move from 798M in 2020 to 1.1G in 2060, while the workforce will grow from 415M to 617M. Consequently, the trend in the future LFDR is about the same as that in the ADR, with little change in the next few decades, followed a by a slow uptick afterwards. Contrary to the ADR, because of its very high starting point, the LFDR never reaches very advantageous levels, as it will stay above 1.65 across the whole time span.

Figures 4 and 5 illustrate how the composition of the population will change according to the Constant Rates Scenario. First, the share of women in the workforce is expected to remain very low, i.e. at below 20% of the workers throughout the projection. A certain heterogeneity exists in the labour force participation rates for women among sub-groups, but still not enough to yield a change in labour force participation rates through a change in the structure of the population. Consequently, the expected expansion in education and the higher urbanisation rate are not likely to impact in any sizable way the women's labour force participation rate and their resulting share within the workforce. In 2060, despite the expected decline in fertility, a larger number of women with postsecondary education in the working age group will be out of the labour force than in the labour force.

**Figure 4. Projected workforce disaggregated by sex and education, Constant Rates Scenario, India, 2020-2060**

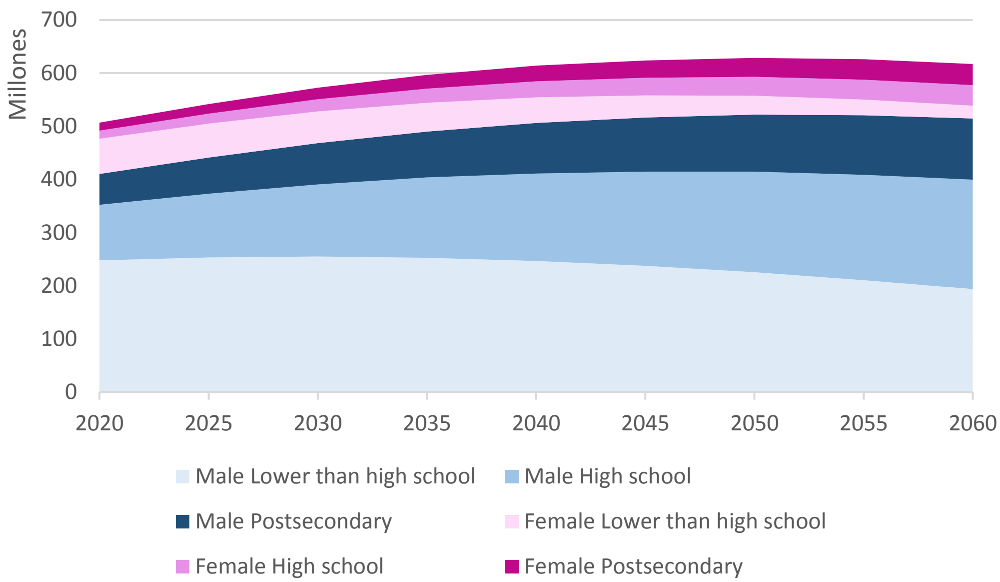
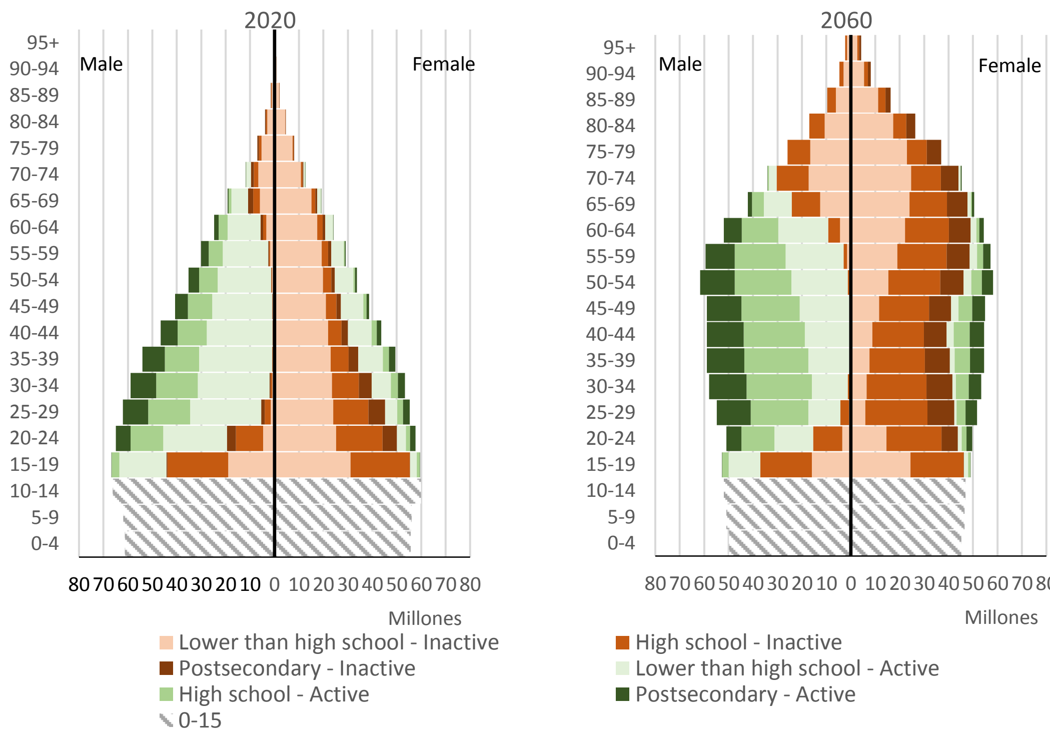



**Figure 5. Age pyramid by education and labour force status, Constant Rates Scenario, India, 2020 and 2060**

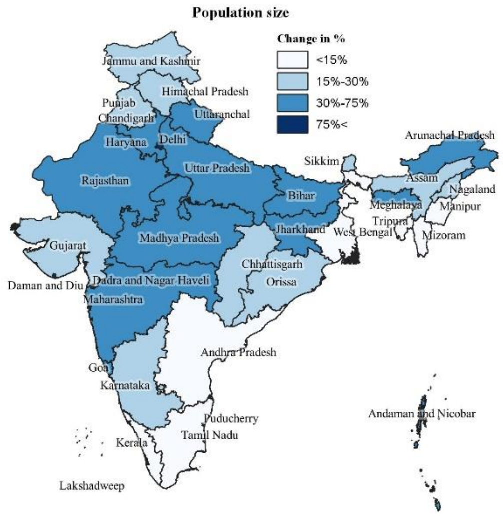


However, the education composition of the labour force is expected to change in the next few decades. In 2020, the highest level of education of almost two thirds of workers was below high school level. This proportion will drop steadily and reach about 35% in 2060. On the other hand, the proportion of workers with postsecondary education will grow by 75%, rising from 14% in 2020 to 25% in 2060. This societal change is mainly driven by demographic metabolism (Lutz, 2013), whereby older uneducated cohorts are gradually replaced by younger ones with a better education.

Among other changes in the labour force composition in India, mention may be made of a strong heterogeneity in the dynamic between urban and rural areas (see Figure 6 in SI). In 2020, about two thirds of workers lived in rural areas. With the expected urbanisation and migration from rural to urban areas, the share of workers in urban areas should increase much faster. By 2060, about half of all workers will be living in cities. While the number of workers will increase constantly throughout the projection in urban zones, in rural areas it is expected to peak in 2040 and plunge into a slow decline directly afterwards. However, since the economically inactive part of the population grows even faster than the active one in urban areas, the labour force dependency ratio will be worse in 2060 compared to 2020 (1.9 vs 1.8), and compared to rural areas (1.8 in 2060). The lower labour force participation rates among women in urban areas than in rural ones explain this dynamic.

By virtue of the fact that India is both very populous and diverse, our projection shows spatial heterogeneity in the projected labour force trends. In figure 6, we show the projected change in the population size and labour force size by state between 2020 and 2060 (see SI Table S4 for detailed results). Since, in this scenario, we assume constant labour force participation rates, the growth in the labour force size and the population size follows approximately the same trends, driven mainly by the current and past fertility levels and, to a lesser extent, by domestic migration (KC et al., 2018).

**Figure 6. Projected change in population and labour force size (%) between 2020 and 2060, Constant Rates Scenario, India**




Regions can be assigned to four broad categories according to their dynamic of projected growth in their respective labour force. First, the small-area regions with high level of urbanisation, for which the increase in the labour force size from 2020 to 2060 is more than three times the country's average (22%). Those regions include Delhi (71%), Chandigarh (73%), Daman and Diu (84%), Dadra and Nagar Haveli (91%) and Lakshadweep (68%). It is also these regions that are seeing the largest relative increase in their total population size as a result of higher fertility and/or a favourable domestic migration dynamic. The second group, whose growth rate is also significantly higher than the country's average includes states in the north-central area. The growth of the labour force thus reaches between 35% to 65% in states such as Bihar (47%), Uttar Pradesh (45%) or Jharkhand (39%). Those states are less developed and have large cohorts of children resulting from higher current and past fertility rates, which drive the future spike in the number of workers. The third group includes states for which the growth in the labour force is around the country's average. These surround the regions of the second group. Finally, the last group consists of those for which the growth in the future labour force is anaemic, or even slightly negative. This category includes all the regions in the south of India and part of the Bengal region. Those regions are more advanced in their demographic transition and are all characterised by low fertility rates compared to the country's average.

However, an examination of the labour force dependency ratio shows a different picture (see SI Table S4 for numbers). First, despite having the largest increase in their labour force size, small-area regions with high urbanisation levels will have a less favourable labour force dependency ratio in 2060 than in 2020. In Delhi, for instance, the ratio is projected to increase from 1.69 to 1.91, and from 1.16 to 1.49 in Chandigarh. The regions in the north-central part of India (Bihar, Jharkhand, Uttar Pradesh and Rajasthan), which will also experience a significant increase in their labour force size, will be the only ones seeing a better ratio in 2060 than in 2020. This is because they are lagging behind in their demographic transition producing a high proportion of children in 2020. Despite this improvement, their LFDR in 2060 is projected to be either comparable (1.98 in Uttar Pradesh) or still less favourable (2.55 in Bihar) than the country's average (1.86). The southern states, on the other hand, started with more favourable LFDRs in 2020, but will see them deteriorate because the increasing share of the elderly population will contribute to an increase in inactive population in the numerator.

**Figure 7. Projected age dependency ratio and labour force dependency ratio, Constant Rates Scenario, 2060, India**

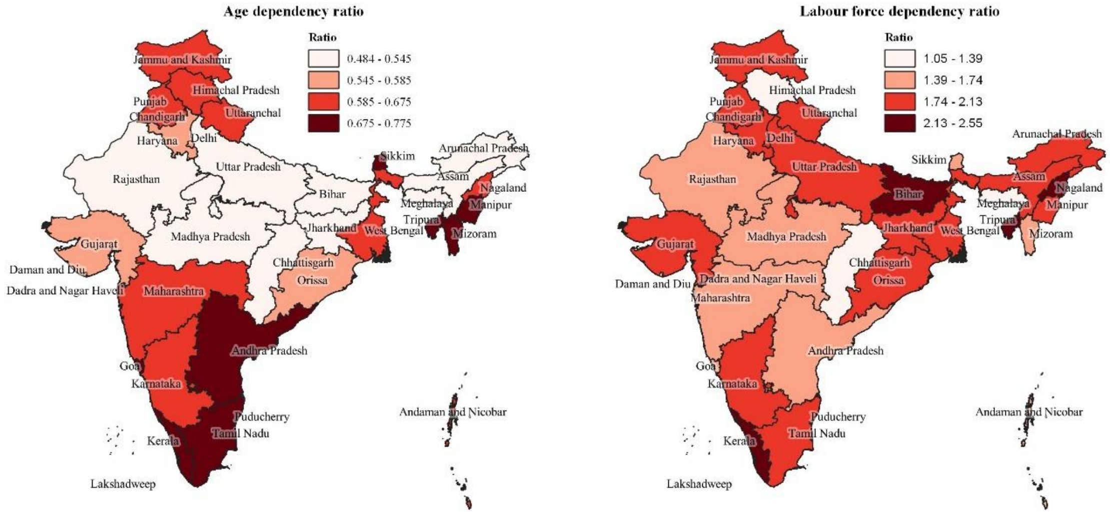



Figure 7 shows the projected age dependency ratio and the labour force dependency ratio in 2060 as per the Constant Rates Scenario. In 2060, regions with the most favourable labour force dependency ratios will be Daman and Diu (1.05), Meghalaya (1.20) and Chhattisgarh (1.22). These regions benefitted from higher fertility rates in 2020, thus postponing the negative effects of population aging and attaining a low age dependency ratio in 2060 (0.48 in Meghalaya; 0.54 in Chhattisgarh; 0.57 in Daman and Diu). They also benefitted from a higher labour force participation of women (see SI Table S2) compared to the country's average, allowing them to have higher numbers of workers within the working-age population. On the contrary, the state of Bihar, despite yielding a similar or even better age-dependency ratio in 2060 (0.52), will have the worst LFDR in all of India in 2060 (2.55) owing to the fact that its female labour force participation is also the lowest in the country. This shows the relevance of including the labour force participation in population projection for a better assessment of the demographic dividend.

## The impact of higher labour force participation of women on the dependency ratio

The results presented above come from the scenario which assumed constant parameters in labour force participation. The changes in aggregated labour force participation rates and dependency ratios thus resulted from changes in the population composition. Figure 8 presents the projected size of the labour force and labour force dependency ratios as per the alternative scenarios on female labour force participation. For the sake of comparison, we have also include the Constant Rates Scenario, the working age and age dependency ratio (which is equal in all the three scenarios), all normalised to 2020=1. Figure 9 illustrates the projected age pyramid by education and labour force status in 2060 for the two alternative scenarios.

**Figure 8. Projected labour force/working age (15-64) size and dependency ratios according to 3 scenarios (2020=1), India, 2020-2060**

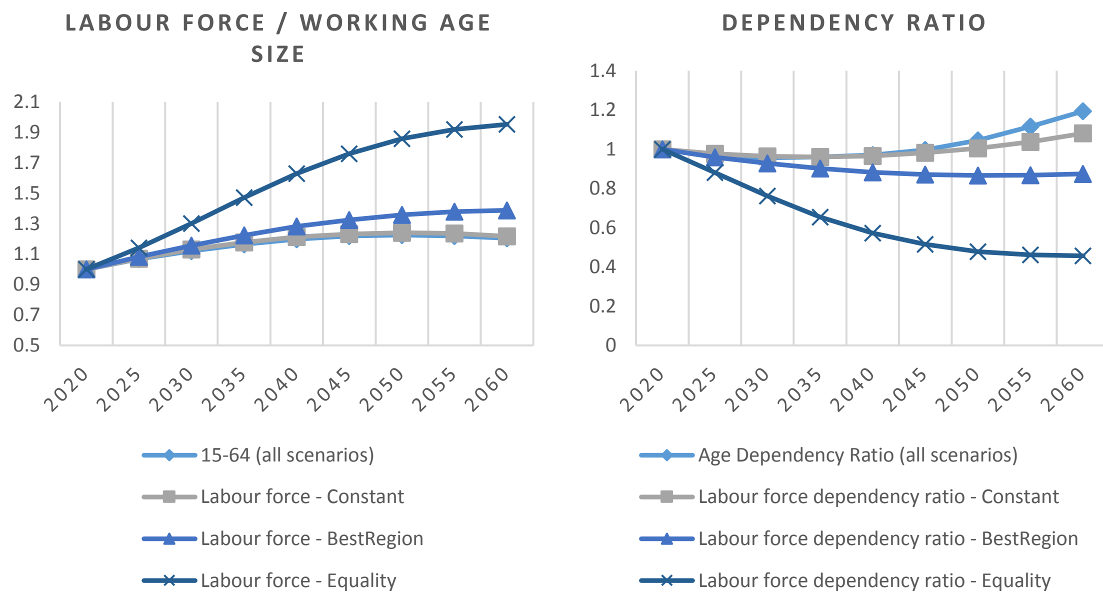


**Figure 9. Projected age pyramid by education and labour force status, BestRegion and Equality Scenarios, India, 2060**


As has already been argued, the age dependency ratio is expected to be relatively stable until 2040 when it is expected to ascend so as to reach, in 2060, a level 20% higher than that from 2020. The labour force dependency ratio, assuming constant parameters, follows a similar trend, though it increases less significantly (about 10% higher in 2060 as compared to 2020).

If an increase in the labour force participation rates of women is assumed, the trends change drastically. The scenario assuming a convergence of female labour force participation with what has been observed in Goa (i.e. the BestRegion scenario) manages to reduce the LFDR by 10% from 2035 compared to 2020 and prevents any further significant increase for the rest of the projection period. By 2060, with a labour force size about 15% higher compared to the Constant Rates Scenario, this scenario should yield a 20% lower LFDR. This is illustrated by the much larger share of green tones in the age pyramid by education and labour force status in Figure 9 as compared with the one from the Constant Rates Scenario (Figure 4). Nevertheless, a strong gender imbalance still remains in this scenario. As shown in Figure 9, a large share of women in the working-age group are inactive (red tones), while these same tones are marginal for men.

The more ambitious Equality Scenario assumes that gender equality in labour force participation will be reached by 2060. As has been illustrated by the age pyramid by education and labour force status, this scenario projects a radically different future, with a prominence of professionally active women within the working-age group in 2060. The total labour force size for India would thus increase to be 60% higher in 2060 than that of the Constant Rates Scenario, and about twice as large as that of 2020. By turning a large proportion of economically inactive women into active ones within the working-age group, the LFDR would represent only 40% of what projected in the Constant Rates Scenario. Starting from 2045, it would decline to as little as 50% of the 2020 value. For the whole country, this scenario is the only one that would yield fewer inactive than active population groups (the 2060 LFDR in absolute value is 0.79 for economically inactive per active, compared to 1.51 for the BestRegion scenario and 1.87 for the Constant Rates Scenario; see SI Table S5 for detailed results).

In both alternative scenarios, regions with the lowest female labour force participation rates in 2020 are also those with the largest gains in the size of the labour force and the largest decrease in the LFDR compared to the Constant Rates Scenario. The state of Bihar, where the labour force participation of women is the lowest as of 2020 (only 4%, see SI Table S3), testifies to this. Bihar's labour force size exceeds that of the Constant Rates Scenario by more than 30% in the BestRegion Scenario and by more than 95% in the Equality Scenario. Conversely, the impact is marginal in the BestRegion Scenario for states where the female labour force participation rates were already close to those observable in Goa (such as Andhra Pradesh and Andaman & Nicobar Islands). In all these cases, however, the impact of the Equality Scenario on the labour force size has been substantial, as the labour force size exceeds at least by 30% that of the Constant Rates Scenario in all the regions, including Goa (43%). In that scenario, most regions would have a LFDR below 1 (see SI Table S5).

## Discussion

This paper has spearheaded novel demographic forecasts of the future of the labour force across all the regions of India up to 2060. This has been achieved by means of devising three different scenarios pertaining to the rates of female labour force participation: the Constant Rates Scenario, the BestRegion Scenario with Goa as the prime example for other states, and the Equality Scenario, which posits the achievement of gender equality by 2060. Due to the fact that those scenarios result in very different outcomes in terms of labour force all while exhibiting about the same demographic structure, our study highlights the relevance of including the labour force as a dimension in population projection. Indeed, the difference in the LFDR in 2060 between the three scenarios (Constant Rates: 1.86, BestRegion: 1.51; Equality: 0.79) is much broader than the difference in the age dependency ratio (ADR) between the high- and low-variant scenarios in the World Population Prospects (0.57 vs 0.48) (United Nations, 2019b).

With the assumption of constant participation rates (Constant Rates Scenario), the projection shows that the dependency ratio expressed in terms of non-workers/workers (LFDR) is very unlikely to attain favourable levels. While the ADR will be low, circa 0.5, for the next few decades, the labour force dependency ratio will not drop below 1.65 because of the very low female labour force participation. In comparison, the ratio for the European Union was 1.08 in 2015 (based on a narrower definition of 'workers') and is expected to only increase to 1.33 in 2060, despite severe population aging, while assuming no change in labour force participation rates (Marois et al., 2020). In the case of India, the comparison between the high LFDR and the low ADR raises concerns as to the potential demographic dividend that the country could gain from its advantageous age-structure.

At the subnational level, the forecast yields the most favourable LFDR in 2060 in regions that combine both a low-age dependency ratio and a higher participation of women. Conversely, a state such as Bihar, which is projected to have the most favourable age structure in 2060, also displays the worst LFDR in the country, because female labour force participation is much lower there than elsewhere in India. In summary, our results suggest that female labour force participation is a better driver of the labour force dependency ratio than the age composition, and that, therefore, it is a conditio sine qua non in order for a country to expect a demographic dividend from its age structure.

Owing to the importance of female labour force participation, the impact of alternative scenarios in which its rates are increased has been assessed. The BestRegion Scenario, in which the rates for all the regions reach those observed in Goa (which is among the leading states in India in this respect) estimates the ratio to decrease by about 20% by 2060 compared to the Constant Rates Scenario. As a reminder, this scenario still presupposes a modest labour force participation for women: 30% among the working-age group, which is below what is observed today in other South Asian countries (39% in Bangladesh and 39% in Sri Lanka), and which is far from reaching the levels observed in more developed countries such as China (60%), Japan (72%) or South Korea (60%) (International Labour Organization, 2020). Indeed, the projected rate for 2060 in this scenario is equivalent to what was observed in India before 2005. A small and realistic change in the labour force participation of women can thus have a large impact on the labour force dependency ratio and, consequently, on the potential demographic dividend.

If gender equality in the labour force participation rates is achieved, the image will be completely different. In the Equality Scenario, the proportion of workers among the total population would be 60% higher in 2060 than in the Constant Rates Scenario. The consequences of such a change in the composition of the population might be considerable. Assuming a constant returns to scale, this scenario should yield a gain in the GDP equivalent to the gain in the proportion of workers within the population (Solow, 1957; Weil, 2005), which is approximately 60% compared to the Constant Rates Scenario and 40% compared to the BestRegion Scenario. If the population size remains unchanged, this gender equality scenario is likely to make India a much wealthier nation in terms of GDP per capita. This outcome is additional evidence for the importance of female labour force participation as a driver of growth and development and a pillar of demographic dividend (Esteve-Volart, 2004; Klasen & Pieters, 2012; Verick, 2018).

Our results thus highlight the importance of increasing female labour force participation in order to fully benefit from the demographic dividend. Accordingly, the government should make available new dynamic policies to overcome barriers encountered by women in the labour market. India has voiced its commitment to achieve the no. 5 United Nations' Sustainable Development Goals by 2030 to provide quality education as well as decent and productive work opportunities for all. In order to boost the quality of education and promote decent employment, the government has articulated its commitment to protect and promote the educational and employment rights of individuals, and of women in particular, scheduled castes, scheduled tribes, backward castes and minorities through various programmes and policies (Government of India, 2020). As emphasized by Srivastava and Srivastava (2010), these constitute the most underrepresented groups in the labour market.

Over the past few decades, higher education has increased rapidly with a higher enrolment of girls in higher and secondary education (WIC, 2019). This makes India a nation endowed with a huge human capital. However, despite this improvement, the labour force participation of women remains low, which raises questions as to the quality of education and skills. Mahapatro (2013) argues that vocational training in the youth population may be able to improve future work participation in India. Kumar et al. (2019) confirm that vocational training has a positive impact on individuals' economic returns and help increase the wages compared to those lacking vocational training. They also accentuate the need for proper vocational training in rural areas, and indicate the need for a greater inclusion of girls in vocational training schemes.

Technical and vocational training programmes for women should be expanded while trying to break the negative stereotypes linked to the increased representation of women in technical and vocational schools. Furthermore, it is essential to identify sectors which have greater potential to employ women in the future. A substantial regional misbalance in training opportunities and skill development institutions (Planning Commission, 2008) poses further challenges for this mission. Our projection outcomes have confirmed uneven regional patterns for the future, which ought to be given due attention. It is also important to consider that the informal sector constitutes the lion's share of the employment market.

In this paper, we have only included the labour force dimension without considering unemployment, job quality, or earnings. Our projection has revealed that future workers will be much more educated than they are nowadays as well as much more likely to live in urban areas. The implications of these changes are multitudinous, as education is highly correlated with the sector of professional activity. Indeed, very few workers with no education work in the formal sector, while the opposite is true for workers with postsecondary education (National Statistical Office, 2019). A spike in the prominence of highly-educated workers is likely to reshape the labour market previously dominated by informal jobs by introducing more formal vacancies, thereby increasing the average productivity of the workers at large (Cáceres-Delpiano, 2012; Lau et al., 1991; McCaig & Pavcnik, 2015; Siggel, 2010). Dewan and Peek (2007) point out that the demand for formal jobs will also increase and is likely to lead to much higher official unemployment rates). Indeed, unemployment is not an option in the context of extreme poverty. The concept of unemployment as defined by the international labour organization is barely applicable to the informal sector, which includes a large part of underemployment, casual, and irregular jobs (Dewan & Peek, 2007). Woetzel et al. (2018) note that India's working age population is growing at a pace of approximately 16 million per annum, but according to the ILO statistics fewer than 2 million vacancies are created every year.

As has rightly been reminded by Goswami (2019), one should tread with caution when analysing FLFP in the Indian context due to the heterogeneity of the different regions and states that could potentially distort the results of such an analysis. Nonetheless, numerous research findings including the ones herein presented serve as reassurance that the analysis of structural economic transformations ought to be reinforced by taking stock of the intricate regional peculiarities that make up the country's social landscape. It is thus only by way of a holistic approach that is cross-disciplinary and keeps in close touch with the realities of Indians' everyday lives that we may eventually be able to outline even more accurate projections into the future of female labour activity in India.

## References

Abraham, V. (2019). The Dynamic Nature of Jobless Growth in India. In K. R. Shyam Sundar, *Globalization, Labour Market Institutions, Processes and Policies in India.* Palgrave Macmillan.

Aggarwal, A., & Kumar, N. (2015). Structural Change, Industrialisation and Poverty Reduction: The Case of India. In N. Naudé, A. Szirmai, & N. Haraguchi, *Structural Change and Industrial Development in the BRICS* (pp. 199–243). Oxford University Press.

Batra, R., & Reio, T. G. (2016). Gender Inequality Issues in India. *Advances in Developing Human Resources*, *18*(1), 88–101. https://doi.org/10.1177/1523422316630651

Bélanger, A., Sabourin, P., Marois, G., Van Hook, J., & Vézina, S. (2019). A framework for the prospective analysis of ethno-cultural super-diversity. *Demographic Research*, *41*(11), 293–330.

Bloom, D. E., Canning, D., Fink, G., & Finlay, J. (2007). Realizing the demographic dividend: Is Africa any different. *Harvard Program on the Global Demography of Aging, Working Paper*, *23.2007*. http://www.harvardschoolofpublichealth.org/pgda/WorkingPapers/2007/pgda_wp23_2007.pdf

Bloom, D. E., & Williamson, J. G. (1998). Demographic transitions and economic miracles in emerging Asia. *World Bank Economic Review*, *12*(3), 419–455.

Boserup, E. (1970). *Woman's Role in Economic Development*. Allen & Unwin.

Cáceres-Delpiano, J. (2012). Can We Still Learn Something From the Relationship Between Fertility and Mother's Employment? Evidence From Developing Countries. *Demography*, *49*(1), 151–174. https://doi.org/10.1007/s13524-011-0076-6

Chatterjee, E., Desai, S., & Vanneman, R. (2018). Indian Paradox: Rising Education, Declining Womens' Employment. *Demographic Research*, *38*, 855–878. PubMed. https://doi.org/10.4054/DemRes.2018.38.31

Chaudhary, R., & Verick, S. (2014). *Female Labour Force Participation in India and Beyond* (ILO Asia-Pacific Working Paper Series).

Cheng, Y. A., & Loichinger, E. (2017). The Future Labor Force of an Aging Taiwan: The Importance of Education and Female Labor Supply. *Population Research and Policy Review*, *36*(3), 441–466. https://doi.org/10.1007/s11113-016-9423-z

Colmer, J. (2016). *Weather, Labour Reallocation, and Industrial Production: Evidence from India* (London School of Economics Job Market Paper).

Crespo Cuaresma, J., Lutz, W., & Sanderson, W. C. (2014). Is the demographic dividend an education dividend? *Demography*, *51*(1), 299–315. https://doi.org/10.1007/s13524-013-0245-x

Das, P. (2011). Trends of Rural Employment in India: Reflections from Recent NSS Data. *Vidyasagar University Journal of Economics*, *XVI*.

Datta Gupta, N., Nandy, D., & Siddhanta, S. (2020). "Opt out" or kept out? The effect of stigma, structure, selection, and sector on the labor force participation of married women in India. *Review of Development Economics*, *24*(3), 927–948. https://doi.org/10.1111/rode.12672

Desai, S. (2010). The Other Half of the Demographic Dividend. *Economic and Political Weekly*, *45*(40), 12–14. JSTOR.

Desai, S., & Andrist, L. (2010). Gender scripts and age at marriage in India. *Demography*, *47*(3), 667–687. https://doi.org/10.1353/dem.0.0118

Dewan, S., & Peek, P. (2007). *Beyond the Employment/Unemployment Dichotomy: Measuring the Quality of Employment in Low Income Countries* (Working Paper No. 83). International Labour Organization.

Esteve-Volart, B. (2004). *Gender Discrimination and Growth: Theory and Evidence from India* (No. DEDPS42; STICERD Discussion Papers). London School of Economics and Political Science.

European Commission. (2015). *The 2015 Ageing Report: Economic and budgetary projections for the 28 EU Member States (2013-2060). European Economy 3/25*. European Commission. http://ec.europa.eu/economy_finance/publications/european_economy/2015/pdf/ee3_en.pdf

Fletcher, K., Pande, R., & Moore, C. T. (2018). *Women and Work in India: Descriptive Evidence and a Review of Potential Policies* (Faculty Research Working Paper No. RWP18-004). Harvard Kennedy School.

Gallaway, J. H., & Bernasek, A. (2002). Gender and Informal Sector Employment in Indonesia. *Journal of Economic Issues*, *36*(2), 313–321. https://doi.org/10.1080/00213624.2002.11506473

Goldin, C. (1994). The u-shaped female labor force function in economic development and economic history. *NBER Working Paper Series*, *No. 4707*, 49.

Golley, J., & Tyers, R. (2012). Demographic dividends, dependencies, and economic growth in China and India. *Asian Economic Papers*, *11*(3), 1–26.

Goswami, D. (2019). Low and declining female work participation: The case of rural West Bengal. *Journal of Labor and Society*, *22*(2), 325–343. https://doi.org/10.1111/wusa.12411

Government of India. (2020). *Annual Report 2019-20*. Department of Social Justice & Empowerment. Ministry of Social Justice and Empowerment.

Gunatilaka, R. (2013). *Women's Participation in Sri Lanka's Labour Force: Trends, Drivers and Constraints.* ILO.

Hirway, I., & Jose, S. (2011). Understanding Women's Work Using Time-Use Statistics: The Case of India. *Feminist Economics*, *17*(4), 67–92. https://doi.org/10.1080/13545701.2011.622289

International Labour Organization. (2019). *ILO Glossary of Statistical Terms*.

International Labour Organization. (2020). *Labor force participation rate, female (% of female population ages 15-64). ILOSTAT database.*

Iyer, A. (2018). Moving from Industry 2.0 to Industry 4.0: A case study from India on leapfrogging in smart manufacturing. *15th Global Conference on Sustainable Manufacturing*, *21*, 663–670. https://doi.org/10.1016/j.promfg.2018.02.169

Kathuria, V., & Natarajan, R. R. (2013). Is Manufacturing an Engine of Growth in India in the Post-Nineties? *Journal of South Asian Development*, *8*(3), 385–408. https://doi.org/10.1177/0973174113504849

KC, S., Wurzer, M., Speringer, M., & Lutz, W. (2018). Future population and human capital in heterogeneous India. *Proceedings of the National Academy of Sciences*, *115*(33), 8328. https://doi.org/10.1073/pnas.1722359115

Klasen, S., & Pieters, J. (2012). *Push or Pull? Drivers of Female Labor Force Participation during India's Economic Boom* (No. 6395; IZA Discussion Papers, p. 34). Institute for the Study of Labor.

Klasen, S., & Pieters, J. (2015). What Explains the Stagnation of Female Labor Force Participation in Urban India? *World Bank Economic Review*, *29*(3), 449–478. https://doi.org/10.1093/wber/lhv003

Kotschy, R., Suarez Urtaza, P., & Sunde, U. (2020). The demographic dividend is more than an education dividend. *Proceedings of the National Academy of Sciences*, *117*(42), 25982. https://doi.org/10.1073/pnas.2012286117

Kumar, R., Mandava, S., & Gopanapalli, V. S. (2019). Vocational training in India: Determinants of participation and effect on wages. *Empirical Research in Vocational Education and Training*, *11*(1), 3. https://doi.org/10.1186/s40461-019-0078-y

Ladusingh, L., & Narayana, M. R. (2012). Chapter 7: Demographic dividends for India: Evidence and implications based on National Transfer Accounts. In D. Park, S.-H. Lee, & A. Mason, *Aging, Economic Growth, and Old-Age Security in Asia* (pp. 203–230). Edward Elgar Publishing Ltd.

Lahoti, R., & Swaminathan, H. (2016). Economic Development and Women's Labor Force Participation in India. *Feminist Economics*, *22*(2), 168–195. https://doi.org/10.1080/13545701.2015.1066022

Lau, L. J., Jamison, D. T., & Louat, F. F. (1991). *Education and productivity in developing countries: An aggregate production function approach* (No. 612; Policy Research Working Paper Series). The World Bank.

Loichinger, E. (2015). Labor force projections up to 2053 for 26 EU countries, by age, sex, and highest level of educational attainment. *Demographic Research*, *32*(15), 443–486. https://doi.org/10.4054/DemRes.2015.32.15

Loichinger, E., & Marois, G. (2018). Education-specific labour force projections for EU-28 countries. In *Demographic & human capital scenarios for the 21st century. 2018 assessment for 201 countries* (pp. 43–52). Publications Office of the European Union.

Lutz, W. (2013). Demographic metabolism: A predictive theory of socioeconomic change. *Population and Development Review*, *38*(Supplement), 283–301. https://doi.org/10.1111/j.1728-4457.2013.00564.x

Lutz, W., Butz, W. P., & KC, S. (Eds.). (2014). *World Population and Human Capital in the Twenty-First Century*. Oxford University Press. http://ukcatalogue.oup.com/product/9780198703167.do

Lutz, W., Crespo Cuaresma, J., Kebede, E., Prskawetz, A., Sanderson, W. C., & Striessnig, E. (2019). Education rather than age structure brings demographic dividend. *Proceedings* *of the National Academy of Sciences*, 201820362. https://doi.org/10.1073/pnas.1820362116

Lutz, W., Goujon, A., KC, S., Stonawski, M., & Stilianakis, N. (Eds.). (2018). *Demographic and human capital scenarios for the 21st century*. Publications Office of the European Union.

Lutz, W., & KC, S. (2011). Global human capital: Integrating education and population. *Science*, *333*(6042), 587–592. https://doi.org/10.1126/science.1206964

Mahapatro, S. R. (2013). Changing Trends in Female Labour Force Participation in India: An Age-Period-Cohort Analysis. *Indian Journal of Human Development*, *7*(1), 83–107. https://doi.org/10.1177/0973703020130104

Mammen, K., & Paxson, C. (2000). Women's Work and Economic Development. *The Journal of Economic Perspectives*, *14*(4), 141–164. JSTOR.

Marois, G., Bélanger, A., & Lutz, W. (2020). Population aging, migration, and productivity in Europe. *Proceedings of the National Academy of Sciences*, *117*(14), 7690. https://doi.org/10.1073/pnas.1918988117

Marois, G., Sabourin, P., & Bélanger, A. (2019). Implementing Dynamics of Immigration Integration in Labor Force Participation Projection in EU28. *Population Research and Policy Review*. https://doi.org/10.1007/s11113-019-09537-y

Mason, A. (2005). Demographic transition and demographic dividends in developed and developing countries. *United Nations Expert Group Meeting on Social and Economic Implications of Changing Population Age Structures*, *31*.

McCaig, B., & Pavcnik, N. (2015). Informal Employment in a Growing and Globalizing Low-Income Country. *American Economic Review*, *105*(5), 545–550. https://doi.org/10.1257/aer.p20151051

Mehrotra, S. (2015). *Seizing the Demographic Dividend: Policies to Achieve Inclusive Growth in India*. Cambridge University Press.

Mitchell, J., & Ashley, C. (2009). *Tourism and Poverty Reduction: Pathways to Prosperity*. Earthscan.

Mitra, A. (2016). Education and earning linkages of regular and casual workers in India: A quantile regression approach. *Journal of Social and Economic Development*, *18*(1), 147–174. https://doi.org/10.1007/s40847-016-0029-4

National Statistical Office. (2019). *Periodic Labour Force Survey 2017/2018*. Government of India.

Navaneetham, K., & Dharmalingam, A. (2012). A Review of Age Structural Transition and Demographic Dividend in South Asia: Opportunities and Challenges. *Journal of Population Ageing*, *5*(4), 281–298. https://doi.org/10.1007/s12062-012-9071-y

Peacock, K., & Finlayson, J. (2009). *Where will the workers come from? British columbia labour force projections to 2030* (p. 24). Business Council of British Columbia Outlook 2020 project.

Permanyer, I., & Smits, J. (2020). Inequality in Human Development across the Globe. *Population and Development Review*, *46*(3), 583–601. https://doi.org/10.1111/padr.12343

Planning Commission. (2008). *Eleventh Five Year Plan 2007-12. Volume-I. Inclusive Growth.*

Rawat, P. S. (2014). Patriarchal Beliefs, Women's Empowerment, and General Well-being. *Vikalpa*, *39*(2), 43–56. https://doi.org/10.1177/0256090920140206

Siggel, E. (2010). The Indian informal sector: The impact of globalization and reform. *International Labour Review*, *149*(1), 93–105. https://doi.org/10.1111/j.1564-913X.2010.00077.x

Solow, R. M. (1957). Technical Change and the Aggregate Production Function. *The Review of Economics and Statistics*, *39*(3), 312–320. JSTOR. https://doi.org/10.2307/1926047

Spielauer, M. (2010). What is Social Science Microsimulation? *Social Science Computer Review*, *29*(1), 9–20. https://doi.org/10.1177/0894439310370085

Srivastava, N., & Srivastava, R. (2010). Women, Work, and Employment Outcomes in Rural India. *Economic and Political Weekly*, *45*(28), 49–63. JSTOR.

Tam, H. (2011). U-shaped female labor participation with economic development: Some panel data evidence. *Economics Letters*, *110*(2), 140–142. https://doi.org/10.1016/j.econlet.2010.11.003

Tisdell, C. A. (2000). *Gender Inequality in India: Evidence from a Rural Survey in West Bengal* (Issue 100037). University of Queensland, School of Economics. https://doi.org/10.22004/ag.econ.100037

Toossi, M. (2006). A new look at long-termlabor force projections to 2050. *Monthly Labor Review*, *November*, 19–39.

United Nations. (2016). Sustainable development goals (SDGs). *United Nations Sustainable Development*. http://www.un.org/sustainabledevelopment/sustainable-development-goals/

United Nations. (2019a). *World Population Prospects 2019. Methodology of the United Nations population estimates and projections*. United Nations, Department of Economic and Social Affairs, Population Division.

United Nations. (2019b). *World Population Prospects: The 2019 Revision*. Department of Economic and Social Affairs, Population Division. http://esa.un.org/unpd/wpp/

Van Hook, J., Bélanger, A., Sabourin, P., & Morse, A. (2020). Immigration Selection and the Educational Composition of the US Labor Force. *Population and Development Review*, *46*(2), 321–346. https://doi.org/10.1111/padr.12315

Van Imhoff, E., & Post, W. (1998). Microsimulation methods for population projection. *Population. English Selection*, *10*(1), 97–138.

Verick, S. (2018). *Female labor force participation and development*. IZA World of Labor.

Weil, D. N. (2005). *Economic Growth, 3rd Edition*. Routledge.

WIC. (2019). *Wittgenstein Centre Data Explorer Version 2.0*. www.wittgensteincentre.org/dataexplorer

Woetzel, J., Madgavkar, A., Sneader, K., Tonby, O., Lin, D., Lydon, J., Sha, S., Krishnan, M., Ellingrud, K., & Gubieski, M. (2018). *The Power of Parity: Advancing Women's Equality in India* [McKinsey Global Institute Report].