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Keywords: COVID-19 Pandemic, Remote Labour Index, Labour Supply Shock, Gross Value Added, ARIMA Modelling

JEL Code: C35, C53, E25, E01, J21, J22, J24, J33, J38

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June 17, 2020

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This paper estimates the first order supply shock through labour supply reduction associated with the containment measures taken by the Government of India to control COVID-19 spread. We make use of two metrics to estimate the labour supply shock. The first metric is based on whether a worker is employed in an essential or a non-essential industry and second measures the extent to which a worker can perform the work activities remotely. For the latter, we construct a Remote Labour Index (RLI) following Rio-Chanona et al. (2020). Using PLFS (2017-18) we find that 116.18 million (25 percent) and 78.93 million (17 percent) workers were affected in Lockdown 1.0 and Lockdown 2.0, respectively, and are at risk of job loss. To get an extensive impact of COVID-19 pandemic on the labour market in India we carry out an in-depth analysis of labour supply shocks by employment status, industry level, and occupation. The expected monthly wage loss of casual workers and regular and salaried employees is estimated to be Rs. 33.8 thousand crores (in 2017-18 prices). Further, the loss in Gross Value Added (GVA) (at 2011-12 prices) is predicted to be between 13 percent and 19 percent during the lockdown period from 25th March to 31st May 2020. The y-o-y quarterly growth rate forecast of GVA (at 2011-12 prices) for Q1:2020-21 is expected to be between -4.6 percent and -8.8 percent, using the baseline model.

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1. Introduction

COVID-19 pandemic has unleashed an unprecedented crisis affecting millions of people around the globe. According to Coronavirus Resource Centre at John Hopkins University, the number of COVID-19 confirmed cases worldwide have exceeded 8 million as of 16th June 2020.[5] As the pandemic spreads, governments face a double challenge of controlling the spread of infections and managing its social and economic impact. To flatten the epidemic curve and contain the virus outspread, measures like lockdown, travel restrictions and strict social distancing norms are required. But at the same time, these containment measures taken by the governments can have detrimental effect on the economy as it puts a large part of the economy to a halt. According to ILO (2020) estimates, countries that have included workplace closures within the COVID-19 containment measures include around 81 percent of the global workforce.[6] As of 22nd April 2020, close to 1.1 billion informal economy workers live and work in full lockdown, with an additional 304 million in countries in partial lockdown (ILO, 2020). Around 68 percent of the workforce (including 81 percent of employers and 66 percent of own-account workers), is currently living in countries with recommended or required workplace closures.

Figure 1 aims to provide an overview of the literature on how the containment measures are triggering supply and demand side shocks across many developed and developing economies around the world.[7] When a pandemic hits an economy both the demand and supply side gets impacted. The demand side is affected due to the change in demand patterns of consumers as they avoid places and activities which a have high risk of exposure and demand more health care services (see Baker et al. (2020a), Baker et al. (2020b), CBO (2006), Muelbauer (2020), OECD (2020)). The supply side gets affected primarily due to the containment measures imposed by the government which restricts the movement of its citizens (see Rio-Chanona et al. (2020), Hicks et al. (2020), Dingel & Neiman (2020), McKibbin & Fernando (2020)). The initial impact of the pandemic on the economy largely comes from the first order supply shocks through labour

[5] See CSSE (2020) COVID-19 Dashboard at https://coronavirus.jhu.edu/map.html. Accessed on 16th June 2020.

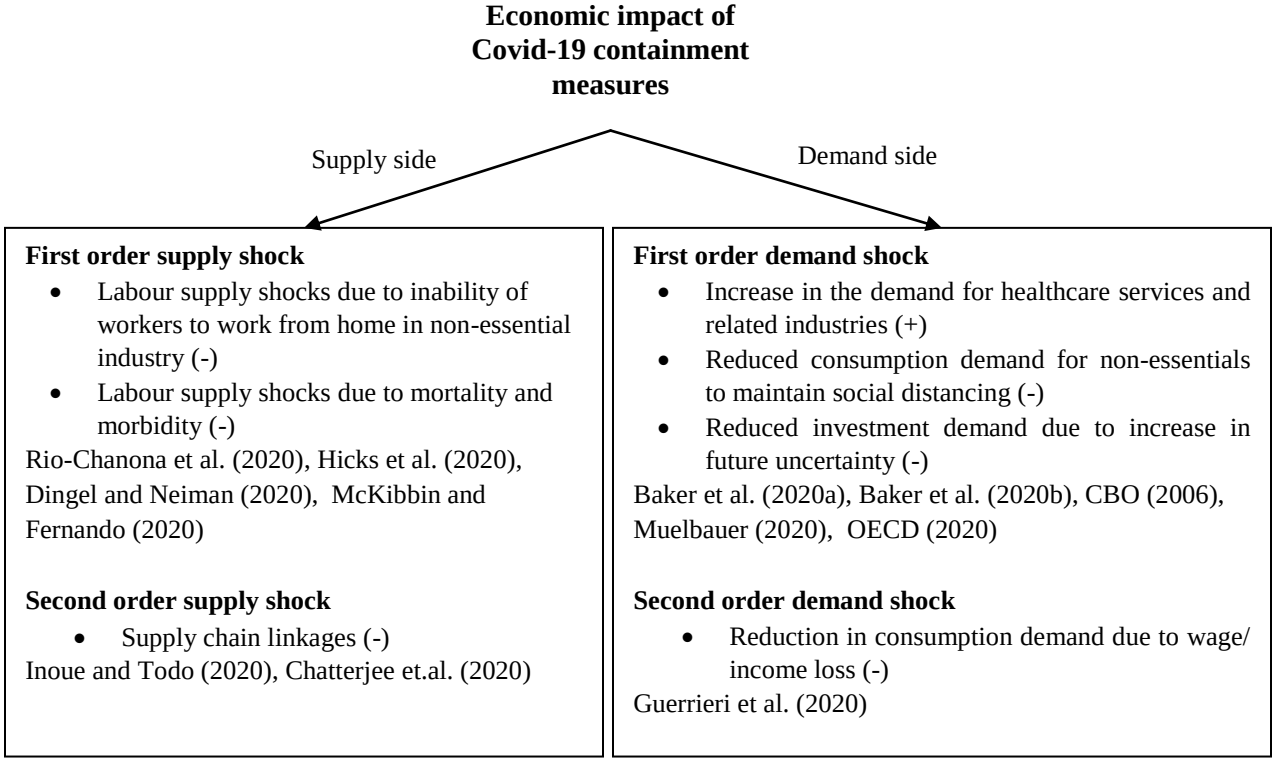
[6] Countries in full lockdown have taken three measures on a mandatory basis (a) workplace closure, (b) restriction on the internal movement of citizens; and (c) shutdown of public transport. Countries in partial lockdown have taken at least one of the three measures on a mandatory basis. Taking into account the additional effects of sectoral risk, employment status, the size of enterprises and different levels of lockdown measures (full, partial and weak measures); about 1.6 billion workers in the informal economy are being significantly impacted. See ILO (2020).

[7] Here we aim to provide an overview of some of the important studies to contextualize the present study. However, the review may not be exhaustive.

supply reductions, as some of the workers in the non-essential industries are unable to perform their work activities (Rio-Chanona et al. (2020)).

The first order supply side disruptions can have sequential second round effects on both demand and supply side of the economy. Inoue and Todo (2020) show that due to strong supply chain linkages, production shut down in one part of the country leads to more than a proportional loss in production for the entire country. According to them, initial shutdown resulted in a 27 percent loss in production in Tokyo, which in turn resulted in a 87 percent loss in production for entire Japan. In another related study Guerrieri et al. (2020) shows that the initial supply shock, resulting in wage and income loss, could lead to more than proportional second order fall in aggregate demand i.e. the fall in aggregate demand in the second-round could be larger than the initial shock itself. Our paper contributes to this growing literature by estimating first order supply shock through a reduction in labour supply [further referred to as labour supply shocks] due to containment measures taken by the Government of India to tackle the spread of the virus.[8]

Figure 1: Supply side and demand side economic impacts of COVID-19 containment measures



[8] For the present analysis we do not consider labor supply reductions due to mortality and morbidity as the percentage share of total deceased to total employed is extremely low.

1.1 Measures taken in India to contain the spread of COVID-19

In India, the number of confirmed COVID-19 infections has reached 3.4 lakhs as of 16th June 2020 and is increasing rapidly (GoI (2020)).[9] To contain the spread of COVID-19, the Government of India issued the first notification on 24th March 2020 which declared a nationwide lockdown for 21 days till 14th April 2020 [further referred to as Lockdown 1.0] (see MHA (2020a)). The first notification along with addendums to it added later, provided a list of activities permitted [also essential] or prohibited [also non-essential] during the Lockdown 1.0 period ((see MHA (2020a)). According to our calculations, first notification rendered activities in 63 percent of 5-digit NIC industries as non-essential and the same were immediately put on halt.

As the number of COVID-19 confirmed cases kept on increasing, the Government of India came up with another notification on 15th April to extend the lockdown by 19 more days, from 15th April till 3rd May [further referred to as Lockdown 2.0] (see MHA (2020b)). During this period, the list of activities permitted was expanded and the restrictions imposed on activities of certain industries were relaxed. According to our estimations, the percentage of non-essential industries reduced to 52 percent and 23 percent in urban and rural areas, respectively, in Lockdown 2.0.

As the situation did not improve much, the lockdown was extended further for 14 days from 4th May 2020 till 17th May 2020 [further referred to as Lockdown 3.0] and subsequently for 14 more days from 18th May 2020 till 31st May 2020 [further referred to as Lockdown 4.0] (see MHA (2020c) and MHA (2020d)). The approach in Lockdown 3.0 and 4.0 was changed and the strictness of measures depended on the risk profiling of the districts with three categories, Red zone (hotspot), and Orange and Green zone. While the lockdown was extremely strict in the Red zone due to the high risk of spread of the virus, some relaxations were given in districts in the Orange and Green zones. Due to increasing concerns on the economic effects of lockdown measures, on 30th May 2020, the Government of India released a notification for a phased re-opening of the economy with some restrictions and strict social distancing norms in place while the lockdown in containment zone is extended till 30th June 2020 [further referred to as Unlock 1] (see MHA (2020e)).

[9] Source: GOI (2020) https://www.mygov.in/covid-19 Accessed on 16th June 2020.

Compared to other countries, India has put in place one of the strictest containment and closure policies in the world, according to the *COVID-19: Government Response Stringency Index* developed by the researchers at the University of Oxford (see Hale et al. (2020)). Most of the highly impacted nations such as the USA, Russia, Brazil, the United Kingdom, Spain, and Italy had a stringency index lower than India for almost the entire duration between 24th March 2020 and 31st May 2020. Moreover, the stringency measures in India are still among the highest in the world according to this index (as on 15th June 2020).

1.2 Informality in India

The Indian economy is characterized by widespread informality in economic activities and the labour market.[10] Table 1 provides a dualistic view of informality in India. About 80.7 percent of workers in all economic activities in India are found in the unorganized sector with only 0.5 percent under formal employment contract within them. Even in the organized sector, the share of workers with informal employment is about 53 percent. Overall, India holds about 91 percent of informal workers in the labour market. As workers with informal employment contract have no job security, income security, health or pension benefits, they are likely to be most affected by an aggregate economic shock like the one we are facing (see Dev and Sengupta (2020), Mehrotra and Parida (2019)).

Table 1: Percentage of workers in organized/ unorganized sector with informal/ formal employment

Sector	Informal Employment	Formal Employment	Total
Organized Sector	9.6	8.6	18.2
Unorganized Sector	80.3	0.5	80.7
Employer household	1.1	0.0	1.1
All	90.9	9.1	100

Source: Authors calculation using PLFS (2017-2018)

1.3 Major findings

While containment measures came at an appropriate time and seemed to countervail the spread of the disease, the Indian economy experienced a severe labour supply shock. According to CMIE, 122 million people went out of job in the month of April 2020, moreover, according to ILO Monitor, 400 million informal workers are at risk of losing their jobs during the crisis (Vyas (2020), ILO (2020)).

[10] The definition used to measure informality, using PLFS 2017-18, is provided in Appendix A.

We undertake a comprehensive approach to arrive at labour supply shock estimates whereby we account for the possibility of labour who is employed in a non-essential industry to work from home. According to our calculation, in March 2020, about 465.3 million people were employed in the Indian labour market out of which 116.18 million (25 percent) and 78.93 million (17 percent) workers were affected in Lockdown 1.0 and Lockdown 2.0, respectively, and are at risk of job loss.[11] The findings reveal that the labour supply shock was mainly concentrated in the urban region and had a negligible impact on the agriculture sector. The most impacted workers, by employment status, are regular and salaried employees followed by own-account workers and casual workers. The latter form the more vulnerable group than regular and salaried employees. However, due to the pervasive nature of informal labour markets in India, even a major chunk of regular and salaried employees are also vulnerable. We estimate that among the regular and salaried workers at risk of job loss, 77 percent (approx.) are informally employed. Moreover, among the workers who are at risk of losing their jobs, 89.5 percent (approx.) are informally employed and 72 percent belong to the unorganized sector during the Lockdown 1.0. We find that most of the labour supply shock is concentrated in *Manufacturing, Trade, hotels, transport, communication & services related to broadcasting* and *Public administration, defence & other services*. Moreover, among the occupations, it is the low skilled jobs which have been impacted the most.

The expected monthly wage loss of casual workers and regular and salaried employees is estimated to be Rs. 33.8 thousand crores (in 2017-18 prices). Further, the estimated loss to Gross Value Added (GVA) (at 2011-12 prices) due to the labour supply shock is expected to be between 13 percent and 19 percent during the lockdown period from 25th March to 31st May 2020. The y-o-y quarterly growth rate forecast of GVA (at 2011-12 prices) for Q1:2020-21 is predicted to range between -4.6 percent and -8.8 percent from the baseline model.

Table 2 shows the percentage of workers at risk of job loss due to lockdown measures in states with the highest number of COVID-19 patients, grouped as Top 5, Top 10 and Top 15.[12] About 40 percent of all the workers who are impacted due to lockdown measures (both Lockdown 1.0 and Lockdown 2.0) are concentrated in Top 5 states with COVID-19 infections. For the next five

[11] We have considered the working age population (15 years and above) for all our estimations. Please note that *labour supply shock* and *workers at risk of job loss* have been used interchangeably throughout the paper

[12] Note that the workers at risk of job loss are estimates of the labour supply shock during lockdown periods.

states, the percentage of workers impacted increases by 30 percent making the Top 10 states having 70 percent workers with a high risk of job loss. About 85 percent of the total workers impacted are concentrated in the Top 15 states. This implies that the job loss is concentrated in states with the highest number of COVID-19 patients. We postulate that the strict social distancing measures will continue to stay in the most affected states, although the intensity might be less. This could then lead to persistence of labour supply shock in most of the major states in India.

Table 2: Percentage of workers at risk of job loss due to lockdown in states with highest COVID-19 infections

States with confirmed COVID-19 cases as on 12th June 2020[13]	Percentage of workers at risk of job loss	
	Lockdown 1.0	Lockdown 2.0
Top 5	39.82	40.45
Top 10	70.06	69.01
Top 15	85.04	85.04

Source: Authors calculation

Given this background, it becomes imperative to study the impact of nationwide lockdown, in general on the Indian economy and in particular on the labour market. This paper attempts to do the same. The structure of the paper is as follows. Section 2 covers in detail the data and methodology used to estimate labour supply shocks and loss of GVA (at 2011-12 constant prices). Section 3 provides results on the labour supply shock, wage loss estimation and loss in GVA (at 2011-12 constant prices). Section 4 concludes with a discussion.

2. Data and Methodology

2.1 Estimation of labour supply shock

To carry out estimations for labour supply shock (both aggregated and disaggregated) we have used Periodic Labour Force Survey-PLFS (2017-18). The estimations are carried out considering both usual principal and subsidiary employment status of the individuals. To obtain absolute numbers, all the estimates are adjusted to the projected population numbers (see Mehrotra and Parida (2019)).[14]

[13] Source: GOI (2020) https://www.mygov.in/covid-19. The states considered are following with decreasing order of Covid-19 cases: Maharashtra, Tamil Nadu, Delhi, Gujarat, Uttar Pradesh, Rajasthan, Madhya Pradesh, West Bengal, Karnataka, Bihar, Haryana, Andhra Pradesh, Jammu and Kashmir, Telengana and Odisha.

[14] We have obtained absolute numbers by multiplying the PLFS estimates with the Census Adjustment Multiplier (CAM). CAM is the ratio of the Census projected population and PLFS estimated population. As the first lockdown was announced by the

The labour supply shock captures those workers who are employed in the non-essential industries and are unable to perform their work activities from home (Rio-Chanona et al. (2020)). These are same as the workers at risk of job loss.[15] To estimate the labour supply shock we consider two metrics. The first metric is defined at an industry level where industries are categorized as 'essential' and 'non-essential'. The second metric captures the potential of work activity to be carried out from home. The Ministry of Home Affairs' initial circular MHA (2020a) prohibited the movement of people for work except, for those working in an essential industry. Moreover, individual workers employed in non-essential industries can stay actively employed if they can work from home. To estimate the extent of a work activity that can be carried out from home, we construct Remote Labour Index (RLI) at an occupation level. The methodology used to generate these two metrics is covered in detail in Section 2.1.1 and 2.1.2, respectively.

2.1.1 Essential and non-essential industry classification

To categorize industries as essential or non-essential, we have used the government notifications issued during Lockdown 1.0 and Lockdown 2.0 (MHA (2020a) and MHA (2020b)). An industry is categorized as essential if it was allowed by the government to operate during the lockdown. It is assumed that if the industry comes under the essential category than the workers working in that industry would not be impacted and thus no resultant job loss would happen in those industries.

In comparison to Lockdown 1.0, some relaxations were given in Lockdown 2.0 specifically in the rural area outside the limits of municipal corporations and municipalities (MHA (2020b)). The classification is done at the National Industrial Classification (NIC) 5-digit level separately for both rural and urban areas. PLFS (2017-18) uses 5-digit classification by NIC (2008) to record the industry of work for the workers (employed persons). There are a total of 1223 5-digit NIC 2008 industries in which workers are employed according to PLFS 2017-18. Table 3 shows the number and the proportion of essential and non-essential 5-digit NIC-2008 industries. As the first lockdown notification did not distinguish between the rural and urban areas, 37 percent of 5-digit NIC industries are identified as essential in both the rural and urban areas. As a result of

Government of India on 24th March 2020, we have used the Census projected population for March 2020 to estimate CAM (Census (2011). We assume that there is no structural change in employment framework between 2017-18 and March 2020.

[15] Note that we use labour supply shock and workers at risk of job loss interchangeably in the paper.

some relaxations during the Lockdown 2.0, the share of 5-digit NIC industries rises to 77 percent in rural areas and 48 percent in urban areas.

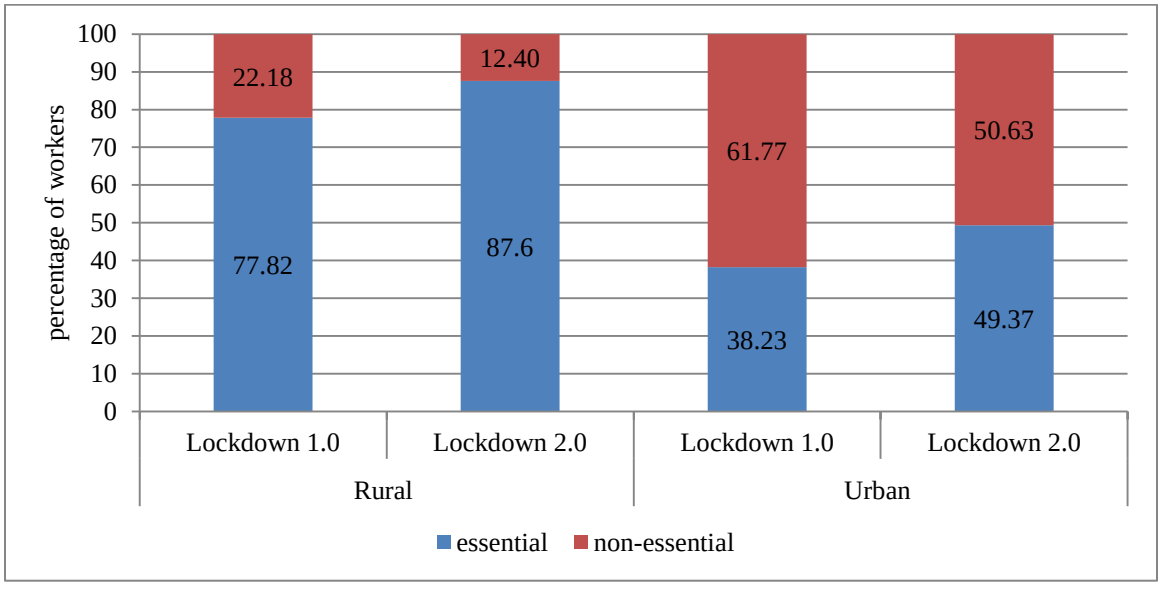
Table 3: Number and proportion of essential and non-essential 5-digit NIC-2008 industries

	Rural				Urban			
	Essential		Non-essential		Essential		Non-essential	
	Number	%	Number	%	Number	%	Number	%
Lockdown 1.0	453	37	770	63	455	37	770	63
Lockdown 2.0	937	77	286	23	593	48	630	52
Total number of 5-digit NIC industries = 1223								

Source: Authors estimation

Figure 2 shows the proportion of workers engaged in essential and non-essential activities during Lockdown 1.0 and Lockdown 2.0 in both rural and urban region. We find that in comparison to the rural area, a higher proportion of workers are engaged in non-essential activities in the urban area during both Lockdown 1.0 and lockdown 2.0. For instance, in Lockdown 1.0, 62 percent of workers in urban areas were engaged in non-essential activity in comparison to 22 percent in rural areas. The same trend continues for Lockdown 2.0. As most of the farming activities are classified as essential by the government notification and are concentrated in rural areas, we find a lower proportion of workers employed in non-essential activities in rural areas.

Figure 2 : Proportion of workers engaged in essential and non-essential industries during the first and second lockdown



Source: Authors estimation using PLFS (2017-18)

2.1.2 Remote Labour Index (RLI)

We undertake a comprehensive approach to arrive at the labour supply shock estimates whereby we account for the possibility of labour that is employed in the non-essential industry and can work from home. Studies have used different approaches to assess different occupations and activities performed by workers and to identify the ones that can be carried out from home. Zhang et al. (2020), surveyed 369 adults in 64 cities in China after one month of confinement due to lockdown and found that 27 percent of the labour force continued working, and 38 percent worked from home. Dingel and Neiman (2020), under the impact of social distancing measures, estimate that in the US, 37 percent of the share of jobs can be performed entirely at home. The authors also apply their occupational methodology to 85 other countries revealing that lower-income economies have a reduced share of occupations that can be performed at home. The international comparison does not include India, but it gives outcomes to Sri Lanka (20.7 percent), Afghanistan (10.9 percent), Maldives (36.6 percent), Nepal (16.8 percent) and Pakistan (13.5 percent). Similarly, Saltiel (2020) finds that few jobs can be done at home, ranging from 5 to 23 percent across the ten developing economies, and reports a positive correlation between this share and GDP per capita. According to Delphi Survey (2020), approximately one in six occupations at the global level and nearly one in three occupations in advanced countries can be done at home– but the potential to do so requires, at a minimum, that countries make the necessary investments in improving telecommunications infrastructure. Finally, Baker (2020), and Koren and Peto (2020) uses O*NET survey data to construct measures of occupations which cannot be done at home or affected by social distancing. Using O*NET survey data Chatterjee et al. (2020) estimate that about 15.9 percent of workers across various occupation types, can work remotely in India.

In this paper, we create our own Remote Labour Index (RLI) for India following Rio-Chanona et al. (2020). Remote Labour Index (RLI) measures the degree of work activity can be performed from home. For each activity within an occupation, $RLI \in [0,1]$, where $RLI = 0$ implies a work activity within an occupation cannot be performed from home and $RLI = 1$ implies a work activity within an occupation can be fully performed from home. We use the National Classification of Occupations, NCO (2015) to map the work activities to the occupation.[16] As

[16] Occupation wise details on work activity is given for NCO (2015) and is unavailable for NCO (2004)

PLFS (2017-18) use NCO-2004 framework, we use the concordance table given in NCO-2015 to match NCO-2004 occupations.[17] To get RLI_{i_k} for each work activity, i, within an occupation, k, we create four subjective and independent sequence of ratings to assess whether a work activity, i_k, can be performed from home or not.[18] Four authors in the paper provide their independent and subjective rating, L_{i_k}, for work activity, i_k. Two scales were used to rate a work activity: binary and a Likert scale of 3. In the case of binary rating 0 implies work cannot be performed from home and 1 implies it can be performed from home.[19] For Likert scale '0' implies work activity is very unlikely to be performed from home, '1' implies work activity is somewhat likely to be performed from home, '2' implies work activity is very likely to be performed from home. As the Likert scale would allow for more variation and captures the close calls while rating work activities in a better way, we use RLI generated using Likert scale to estimate the labour supply shock in this paper.[20] This paper differs from Rio-Chanona et al. (2020) as they considered a binary scale to construct RLI.

RLI for k^{th} occupation, RLI_k, using 3 point Likert scale is defined as follows,

$$RLI_k = \frac{1}{4n_k} \sum_{j=1}^{4} \sum_{i_k=1}^{n_k} \left(\frac{L_{i_k,j}}{\max\left\{\bar{L}_{i_k}\right\} - \min\left\{\bar{L}_{i_k}\right\}} \right) \quad \text{Eq. 1}$$

where, n_k is total number of work activities for k^{th} occupation, i_k is the ith work activity within k^{th} occupation, $L_{i_k,j}$ is the rating given by jth rater for ith work activity for k^{th} occupation and $\bar{L}_{i_k}$ is the set of possible ratings for ith work activity within k^{th} occupation.[21]

Figure 3 below shows Remote Labour Index (RLI) scores for occupational groups averaged at NCO 1- digit level from scores generated at NCO 3 – digit level.[22] On an average**,** group of

[17] As PLFS collects data at NCO 3 –digit level, the mapping of work activities and occupation is done at that level

[18] The study makes the following assumptions, first, the occupation and related work activities are independent of other occupations with similar or different work activities and, second, all the work activities within an occupation carry an equal weightage for all occupational groups.

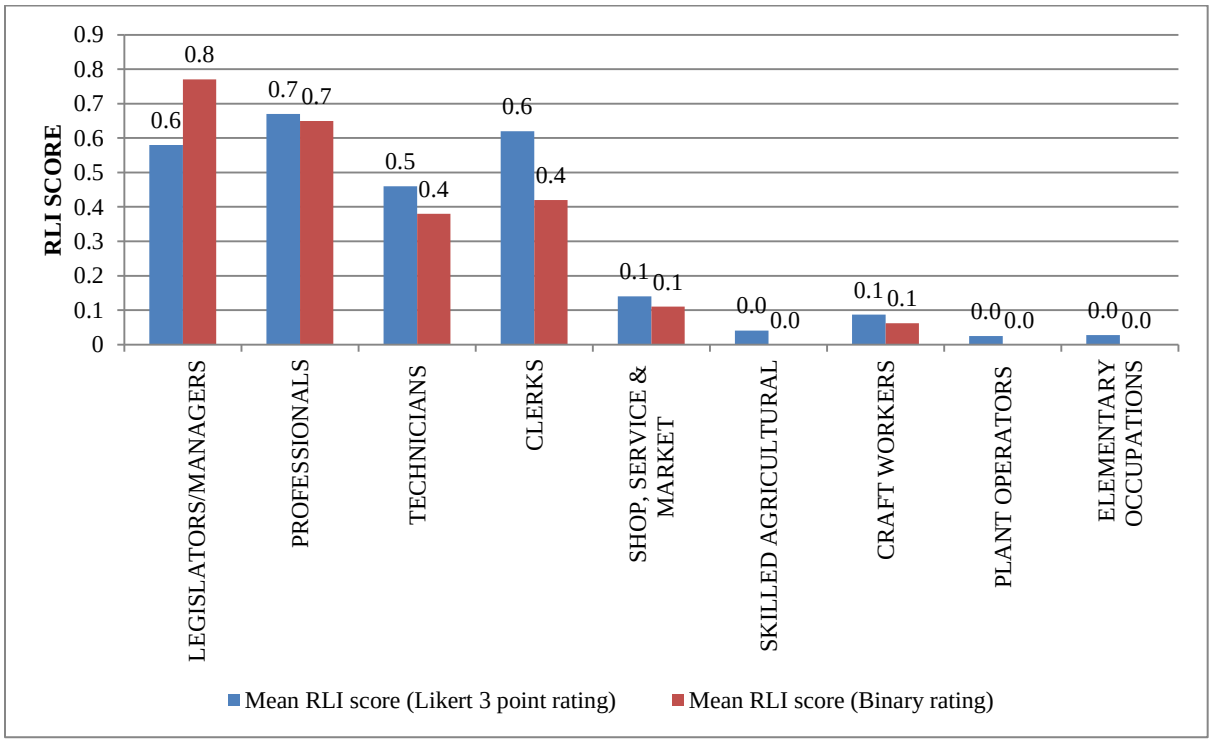
[19] For binary scale we considered an activity can be performed from home if 3 or more raters have agreed on it.

[20] As a robustness check we estimated the correlation between the RLI scores using binary and Likert scale. We found that there is 87 per cent correlation between the RLI scores generated using both the binary and Likert scale.

[21] The rating is given by four raters from possible values {0,1,2}. Since the possible ratings do not vary for raters, the value of $\max\left\{\bar{L}_{i_k}\right\} - \min\left\{\bar{L}_{i_k}\right\}$ remains the same across j. Also, the possible set of ratings is uniform for all $i_{k,}$, thus the value of $\max\left\{\bar{L}_{i_k}\right\} - \min\left\{\bar{L}_{i_k}\right\}$ would be 2 for all. Note that the ratio $\frac{L_{i_k,j}}{\max\left\{\bar{L}_{i_k}\right\} - \min\left\{\bar{L}_{i_k}\right\}}$ normalises rating for each rater j for a given $i_{k,}$ to a scale of [0,1].

workers who are at risk of losing jobs belong to those occupations which have low RLI. Occupations such as service workers, machine operators and elementary occupations have an average RLI score of 0.1, which implies that they have extremely limited means, scope and ways to carry out work activities remotely from home. On the other hand, we find that Legislators, Senior Officials and Managers, professionals, technicians and clerks all have an average RLI greater than or equal to 0.5 (Figure 3).[23] This implies that RLI is low for most of the low skilled workers and these are at a greater risk of losing their jobs.

Figure 3: Average Remote Labour Index (RLI) scores at NCO 1- digit level division



Source: Authors estimation using PLFS (2017-18)

[22] The detailed table of RLI at NCO 3 – digit level is available in Appendix D.

[23] The occupational group clerk has high RLI as it involves work activities such as 'checking and formatting documents prepared by other staff, deal with incoming and outgoing mail', 'screen requests for meetings or appointments, and perform a variety of administrative support tasks', 'obtain, compile and compute accounting, bookkeeping, statistical, financial, and other numerical data, and take charge of cash transactions incidental to business matters' and 'provide or obtain information in person, by telephone or electronic means such as e-mail in connection with making travel arrangements, describing the products or services of an organization, registering and greeting guests and visitors, making appointments, connecting telephone calls and collecting information from survey respondents or applicants for services' pertaining to secretaries, numerical clerks and client information clerks respectively have rightly received a high score from the raters, justifying the high scores received by occupational group clerks.

2.1.3 Measurement of labour supply shock

To estimate labour supply shock we need to account for both the extent to which the work can be done from home and whether the worker is employed in the essential or non-essential industry. The labour supply shock for an occupation k within an industry q, $\Delta L_{q,k}$, is calculated as follows,

$$\Delta L_{q,k} = \begin{cases} \sum_{p_{q,k}} (1 - RLI_k) \times Z_{p_{q,k}} : & \text{worker } p \text{ working in non} - \text{essential industry} \\ 0 : & \text{worker } p \text{ working in an essential industry} \end{cases} \quad \text{Eq. 2}$$

For a worker p working in an essential industry, labour shock would be 0, thus labour shock for all occupations k within these industries would be zero. On the contrary, if a worker p with occupation k works in a non-essential industry then the labour loss would depend on the proportion of work that cannot be done from home i.e. $(1 - RLI_k)$. If an occupation can perfectly be done from home than RLI_k would be 1 and labour shock would thus be 0. To get labour shock for an industry q and a particular occupation k, $\Delta L_{q,k}$, we need to aggregate labour loss for all workers $p_{k,q}$ within the industry adjusted by the weighted representation of a worker in the population $Z_{p_{k,q}}$. Aggregating $\Delta L_{q,k}$ over all the occupations k would give us industry specific labour supply shock, ΔL_q. Aggregating ΔL_q over all industries q would give us economy-wide aggregate labour shock,

$$Aggregate\ labor\ supply\ shock = \sum_{q=1}^{n} \Delta L_q \quad \text{Eq. 3}$$

where industry specific labour supply shock $\Delta L_q = \sum_{k=1}^{m_q} \Delta L_{q,k}$, m_q is the total number of occupations within an industry q and n is the total number of industries within an economy.

2.1 Estimation of Gross Value Added loss

We use these labour supply shock estimates discussed in the previous section to further calculate estimates on gross value added (GVA) lost at industry level during the lockdown period from

25th March to 31st May 2020. The total output loss, $\Delta Y_{q,t}$, for industry q in time period t is estimated as follows,

$$\Delta Y_{q,t} = MPL_{q,t} \times \Delta L_{q,t} \quad \text{Eq. 4}$$

In the above equation, $MPL_{q,t}$ and $\Delta L_{q,t}$ are the marginal product of labour and labour supply shock for industry q, respectively. In the baseline model, we assume a competitive setting and a Cobb-Douglas production function for industry q. The estimates for gross value added loss is estimated using the following equation,[24]

$$\Delta Y_{q,t} = \alpha_q \times \frac{Y_{q,t}}{L_{q,t}} \times \Delta L_{q,t} \quad \text{Eq. 5}$$

where $0 < \alpha_q < 1$ is the industry specific labour income share in output and $L_{q,t}$ is labour input to production.[25] The time period $t = 1, 2, 3, 4$ refers to the four lockdown periods from 25th March to 31st May 2020. The four periods being: Lockdown 1.0 (25th March-14th April), Lockdown 2.0 (15th April-3rd May), Lockdown 4.0 (4th May-17th May) and Lockdown 4.0 (18th May-31st May). We use ARIMA modeling to forecast sector-wise Gross Value Added for 2020-2021 Q1 and then use interpolated series to estimate gross value added losses for four lockdown periods.[26]

To get industry wise share of labour income in the gross value added, α_q, in **Eq. 5** we use KLEMS (2019) database. The labour income share in gross value added provided for Indian economy for 2016-17 is used here.[27] For the current analysis, we assume that the labour income share in gross value added for each industry level has not changed since 2016-17.[28] To derive **Eq. 5** we assume a Cobb-Douglas production function where capital and labour are imperfect substitutes. It is possible that in certain industries capital and labour are complementary especially in Manufacturing where machines (capital) cannot work without being operated by labour. In such cases, labour loss would lead to proportional fall in output such that, $\frac{\Delta Y_{q,t}}{Y_{q,t}} = \frac{\Delta L_{q,t}}{L_{q,t}}$.

[24] Please refer to Appendix C for details on the derivation.
[25] Note that $\boldsymbol{\alpha_q}$ is independent of time as it is assumed that the labour share in income does not change over a short period of time considered for analysis here.
[26] We interpolate the quarterly series to daily series as the lockdown periods are not regular. To do this, we use quadratic sum interpolation here. The results are robust to alternate method of interpolation.
[27] KLEMS (2008) database provides annual data on labour share in value added from 1980-1981 to 2016-17.
[28] The value of labour income share in gross value added has not deviated much over the last five years of available data series.

Further, we simulate Model 2 with complementary capital and labour in the Manufacturing industry. To do this we assume, $\alpha_m = 1$, such that the output loss in the manufacturing industry, $\Delta Y_{m,t} = \frac{\Delta L_{m,t}}{L_{m,t}} \times Y_{m,t}$.[29] The value of $L_{i,t}$ used here is the value of total employment level in March 2020 as calculated by authors using the PLFS 2017-18 database for all t. We use estimates on labour supply shock at an industry level q, $\Delta L_{q,t}$, estimated in the previous section for different lockdown periods in Eq. **5**. $\Delta L_{i,1}$ and $\Delta L_{i,2}$ refers to labour supply shock due in Lockdown 1.0 and Lockdown 2.0, respectively. Further it is assumed that labour supply shock, $\Delta L_{q,t}$, for $t = 3$ and 4 is same as labour supply shock $\Delta L_{q,2}$ i.e. for time period 2. During Lockdown 3.0 and 4.0, Centre's directive was relaxed on certain economic activities only in limited Green zones (see MHA (2020c) and MHA (2020d)). Moreover, the inter-state movement of vehicles was still restrictive throughout the country which would make it extremely difficult to resume economic activities even in the Green zone as industries are connected to each other. This is consistent with COVID-19: Government Response Stringency Index created by Hale et.al (2020) which is reduced by less than 20 percent during Lockdown 3.0 and 4.0.[30] We approximate the industry specific output level, $\boldsymbol{Y_q}$, using gross value added (GVA) at basic prices (at 2011-12 prices). Gross value added (GVA) at basic prices series (at 2011-12 prices) is the same as real gross domestic product (GDP) at factor cost.[31]

We use quarterly gross value added (GVA) data at constant prices (2011-12) for eight sectors of the economy from Q1:2011-2012 till Q4:2019-2020 for our analysis. The eight sectors are namely: 1. Agriculture, forestry & fishing; 2. Mining & quarrying; 3. Manufacturing; 4. Electricity, gas, water supply & other utility services; 5. Construction; 6. Trade, hotels, transport communication & services related to broadcasting; 7. Financial, real estate & professional services; 6. Public administration, defence and other services.[32] The gross value added by all the eight sectors sums to gross value added (GVA) at constant prices in an economy in the given time period. To get gross value added estimates for the lockdown period (25th March, 2020-31st

[29] See Appendix C for details.
[30] This composite measure is a simple additive score of nine indicators measured on an ordinal scale, rescaled to vary from 0 to 100 (100 = strictest response). India stayed at 100 on this index between March 25 and April 19, 2020. On April 20, it was relaxed slightly to 96.3, and on May 04 to 81.94, after the government eased norms workplaces in regions outside the red zones. On May 18, 2020 it was again slightly reduced to 79.17 which remained at that level till May 31, 2020.
[31] The relationship between GVA at basic prices and GDP at market prices is described as follows:

$$GDP_{Market\ Prices} = GVA_{Basic\ Prices} + Taxes_{Product} - Subsidies_{Product}$$

[32] We use this classification of major economic activities for further analysis in the present paper.

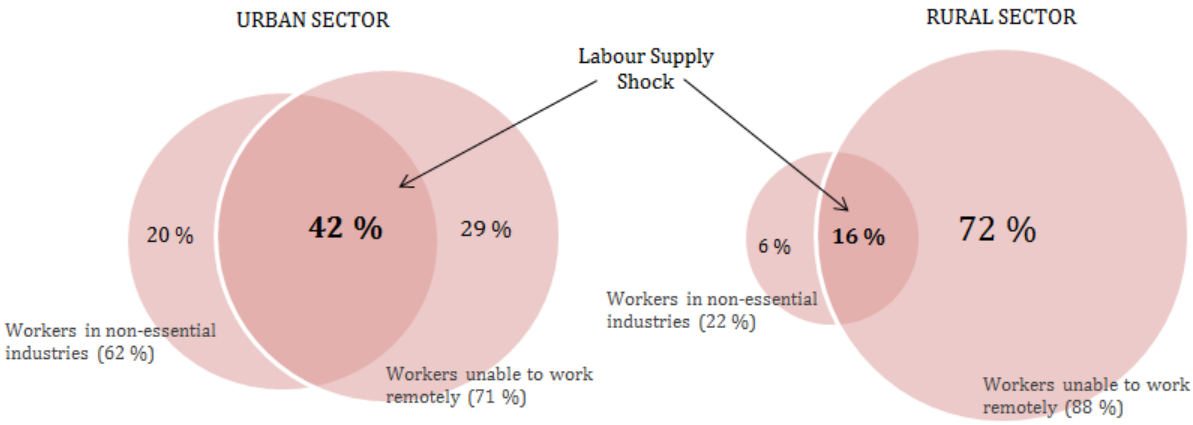
May, 2020), we forecast the gross value added series by major economic activities using ARIMA modelling. [33] The data from Q1:2011-2012 to Q3:2019-2020 is sourced from EPWRF (2020) database and from Q4:2019-2020 from the latest estimates of national accounts statistics in MOSPI (2020). We use ARIMA modelling to forecast industry wise Gross Value Added for Q1:2020 and then use interpolation to get no COVID-19 scenario forecasts. Then using Eq. **5**, we estimate GVA loss at an industry level q for lockdown period t.[34]

3. Results

3.1 Aggregate labour supply shock estimations

Figure 4 and Figure 5 are graphical representations summarizing the percentage of workers affected during Lockdown 1.0 and 2.0, respectively. During Lockdown 1.0 around 42 percent of workers in the urban areas and 16 percent of workers in the rural areas were impacted. There are 20 percent and 6 percent workers in the urban and rural areas, respectively, who belong to the non-essential industry and can work remotely. Moreover, among the workers who cannot work remotely 29 percent and 72 percent in the urban and rural areas, respectively, are employed in essential industries and thus are not affected.

Figure 4: Percentage of workers impacted during Lockdown 1.0

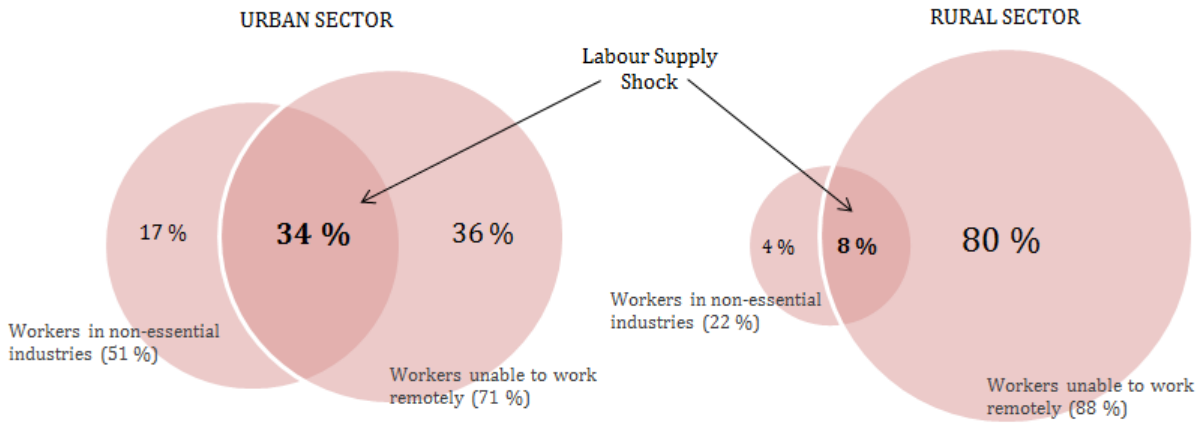


Similarly, for Lockdown 2.0, 8 percent and 34 percent of workers in rural and urban areas, respectively, impacted. There are 17 percent and 4 percent of workers in urban and rural areas,

[33] The detailed on ARIMA model fitted for each industry level series is described in Appendix C.
[34] We use quadratic (sum) interpolation to change the data frequency from low to high. Since the lockdown phases have irregular periodicity we interpolate data to a daily level. The results of GVA loss are robust to the method of interpolation used here.

respectively who belong to non-essential industry and can work remotely. Moreover, among the workers that cannot work remotely 36 percent and 80 percent in urban and rural areas, respectively, are employed in essential industries and thus are not affected.

Figure 5: Percentage of workers impacted during Lockdown 2.0



In the aggregate economy, about 116.18 million (25 percent) and 78.93 million (17 percent) workers were affected in Lockdown 1.0 and Lockdown 2.0, respectively, and are at risk of job loss (Table 4).

Table 4: Region wise number of workers at risk of job loss

Region	Total number of workers -in millions	Lockdown 1.0 – in millions (% of total)	Lockdown 2.0– in millions (% of total)
Urban	155.90	65.50 (42.01)	53.21 (34.13)
Rural	309.41	50.69 (16.38)	25.72 (8.31)
Total	465.31	116.18 (24.97)	78.93 (16.96)

Source: Authors estimation using PLFS (2017-18)

3.2 Labour supply shock by employment status

Employment in India is characterized by two major categories, those that are self-employed (the majority of which are own-account workers), and those that are defined as wage earners. The latter refers to those with an employment relationship linked through the payment of wages. Under this category, the NSSO has subdivided workers into regular/salaried and casual wage

employment. According to PLFS 2017-18, 52.2 percent of the workers are self-employed, 22.8 percent are regular and salaried employees and 24.9 percent are casual workers in India.

The casual labour market consists mainly of people from economically poorer households, engaged in irregular work, compensated on a daily basis and with low levels of education and skills (Rani and Belser (2012)). The incidence of such labour is high among socially disadvantaged groups.[35] Casual workers are usually under-employed as working cycles are irregular and they are compensated only for days worked (ILO, 2018). These characteristics of workers engaged in casual labour put them in the most vulnerable category amongst the compensated workers. With little or no job and income security, they are likely to suffer the most upon any economic shock such as the one we are facing. Regular or salaried workers, on the other hand, have continuous employment and their wage compensation is made periodically (weekly or monthly).

The other half of the workforce comprises of the self-employed individuals. Self-employment is composed of employers, unpaid family workers, and own-account workers. The latter constitutes the biggest group.[36] Most of these own-account workers are also home-based workers and home workers and their income fluctuates the same as casual workers. The biggest challenge is that they are undercounted and unrecognized (ILO, 2018).

According to our estimates, the workers who are significantly impacted due to the lockdown measures are regular and salaried wage earners, followed by casual workers and own-account workers. In Lockdown 1.0, of the total workers in each employment status category, 44 percent regular and salaried employees, 20 percent of own-account workers and 22 percent of casual workers are found at risk of job loss. Although the overall proportion for workers who are at risk of losing their jobs has reduced for each employment category in Lockdown 2.0, the reduction is significant for casual workers (Table 5).

In both the lockdown period, the regular and salaried employees are the most affected group. Among the total regular and salaried employees who are at risk of losing a job, 77 percent (approx) are informally employed (Table 6). This implies that these regular and salaried workers

[35] According to PLFS 2017-18, 46.3 percent of casual workers belong to schedule caste and schedule tribe group. 38.6 percent belong to the 'other backward class' category.

[36] According to PLFS 2017-18, of the self-employed 70 percent are own-account workers, 26 percent unpaid family members and 4 percent (approx.) are employers.

receive no social security benefits, and are more vulnerable than those who are formally employed (see Section 3.2.1).

Table 5: Employment status wise number and proportion of workers at risk of job loss

Employment status	Total workers (in millions)	Job loss (in millions) (percentage loss)	
		Lockdown 1	Lockdown 2
own-account worker	168.43	34.24 (20.33)	24.61 (14.61)
employer	9.53	1.44 (15.13)	0.87 (9.16)
contributing family members	60.53	5.64 (9.31)	3.71 (6.12)
regular and salaried employee	113.96	49.78 (43.68)	36.97 (32.44)
casual worker	112.85	25.08 (22.22)	12.78 (11.32)
Total	465.31	116.18 (24.97)	78.93 (16.96)

Source: Authors estimation using PLFS (2017-18)

3.2.1 Informality and employment status

An Indian economy is characterized by widespread informality in economic activities and the labour market. Workers with informal employment contract have no job security, income security, health or pension benefits and they are likely to be most affected by an aggregate economic shock like the one we are facing (see ILO (2020), Dev and Sengupta (2020), Mehrotra and Parida (2019)).

We have provided job loss estimates using the dualistic framework of informality where we account for the possibility and intersection of formal/informal employment and organized/unorganized sector. According to the dualistic framework of informality, there is a possibility of a worker employed in the organized sector and informally employed and vice versa. For this paper, we have come up with the following six groupings for informality:

1. FOS = Formal employment in organized sector,
2. IOS = Informal employment in organized sector,
3. FUS = Formal employment in organized sector,

4. IUS = Informal employment in unorganized sector,
5. FEH = Formal Employer's household,
6. IEH = Informal Employer's household

Table 6: Employment status and informal category wise proportion of workers at risk of job loss

Employment status	Lockdown 1: Job loss in millions (percentage loss)						
	FOS	**IOS**	**FUS**	**IUS**	**FEH**	**IEH**	**Total**
own-account worker	0.33 (0.96)			33.91 (99.04)			34.24 (100.00)
Employer	0.07 (4.99)			1.37 (95.01)			1.44 (100.00)
contributing family member		0.12 (2.09)		5.52 (97.91)			5.64 (100.00)
regular and salaried employee	10.71 (21.52)	13.24 (26.59)	0.78 (1.56)	20.59 (41.37)	0.10 (0.21)	4.35 (8.75)	49.78 (100.00)
casual worker	0.13 (0.51)	6.47 (25.79)	0.03 (0.12)	17.71 (70.61)	0.00 (0.00)	0.74 (2.97)	25.08 (100.00)
Total	11.24 (9.68)	19.82 (17.06)	0.81 (0.70)	79.10 (68.08)	0.10 (0.09)	5.10 (4.39)	116.18 (100.00)
Employment status	**Lockdown 2: Job loss in millions (percentage loss)**						
	FOS	**IOS**	**FUS**	**IUS**	**FEH**	**IEH**	**Total**
own-account worker	0.26 (1.07)			24.35 (98.93)			24.61 (100.00)
Employer	0.04 (5.05)			0.83 (94.95)			0.87 (100.00)
contributing family member		0.09 (2.41)		3.62 (97.59)			3.71 (100.00)
regular and salaried employee	8.37 (22.64)	9.96 (26.94)	0.57 (1.53)	13.61 (36.83)	0.10 (0.28)	4.35 (11.78)	36.97 (100.00)
casual worker	0.08 (0.62)	2.20 (17.22)	0.03 (0.24)	9.72 (76.10)	0.00 (0.00)	0.74 (5.82)	12.78 (100.00)
Total	8.76 (11.09)	12.25 (15.52)	0.60 (0.76)	52.13 (66.04)	0.10 (0.13)	5.10 (6.46)	78.93 (100.00)

Source: Authors estimation using PLFS (2017-18)

Table 6 provides figures for workers who are at risk of job loss across employment status category and belong to one of the informality groupings. [37] Among the six grouping IOS, IUS and IEH together constitute informal employment and FUS and IUS together constitute employment in the unorganized sector. Workers employed in the IUS category form the most vulnerable group. We find that, among the workers who are at risk of losing jobs during Lockdown 1.0, 68 percent (approx.) belong to the IUS category. Among all the workers who are at risk of losing jobs during Lockdown 1.0, we find that 89.5 percent (approx.) workers are informally employed and 72 percent belong to the unorganized sector.

In absolute numbers, out of 116 million workers who are at risk of losing jobs, 104 million workers are informally employed. Around 79 million workers belong to vulnerable IUS category and thus have a higher risk of losing their jobs in Lockdown 1.0 (Table 6).

3.3 Labour supply shock by industry

Industrial group wise labour supply shocks are driven by the proportion of workers employed in non-essential activity and the extent to which they cannot work from home. Table 7 provides an industrial group wise proportion of workers who can work remotely and non-essential activities. In Lockdown 1.0, top 3 industrial groups with the highest proportion of non-essential activities are *Manufacturing, Trade, hotels, transport communication & services related to broadcasting* and *Public administration, defence and other services.* Among them, *Manufacturing* has the lowest RLI.

The trend provided above follows the job loss figures provided in Table 8. This table provides an industrial group wise proportion of workers, of the total workers, at risk of job loss. In Lockdown 1.0, the most affected sector is *Manufacturing* in which 64 percent of the workers are at risk of job loss. The other most affected sectors are *Trade, hotels, transport communication & services related to broadcasting* (45.38 percent of workers are affected) and *Public administration, defence and other services* (36.35 percent of the workers are affected).

[37] A detailed methodology on groupings of informality is given in Appendix A.

Table 7: Industrial group wise proportion of workers can work remotely and proportion of non-essential activities

Industry	% of workers employed in non-essential activity		% can work remotely
	Lockdown 1.0	Lockdown 2.0	
Agriculture, forestry & fishing	0.04	0.02	5.67
Mining & quarrying	22.54	4.38	10.15
Manufacturing	83.39	54.19	23.06
Electricity, gas, water supply & other utility services	0.00	0.00	20.88
Construction	31.04	11.32	4.00
Trade, hotels, transport communication & services related to broadcasting (Trade)	62.51	38.88	27.78
Financial, real estate & professional services (Finance)	46.67	46.37	47.54
Public administration, defence and other services (other services)	70.37	70.37	42.56
Total	33.52	23.35	16.68

Source: Authors estimation using PLFS (2017-18)

Moreover, in Lockdown 2.0, the same industrial groups remain the most affected. However, a disaggregated analysis shows that proportions of workers at risk of job loss reduced significantly in Construction and wholesale trade. This is because many activities belonging to these sectors were allowed to operate, especially in rural areas, during Lockdown 2.0. Moreover, the sub-industrial groups which were significantly affected during Lockdown 1.0 and 2.0 are accommodation, transport, real estate, arts and entertainment and other services (it includes activities of member organizations repair of household goods and other personal services).

Table 9 shows the occupation wise proportion of workers who are at risk of job loss**.** On average**,** the workers who are at risk of losing jobs belong to those occupations which have low RLI. Occupations such as service workers, machine operators and elementary occupations have an average RLI score of 0.1 and most of the workers who are at risk of job loss belong to these occupations. These are primarily low skilled workers and have limited means, scope and ways to carry out work activities remotely from home. On the other hand, less than 10 percent of the affected workers belong to high skilled occupational groups such as Legislators, Senior Officials and Managers, professionals, technicians and clerks.

Table 8: Industrial group wise proportion of workers at risk of job loss

Industry	Total number of workers (in millions)	Workers at risk of job loss as % of total workers	
		Lockdown 1.0	Lockdown 2.0
Agriculture, forestry & fishing	193.29	0.04	0.01
Mining & quarrying	1.93	20.51	4.43
Manufacturing	59.81	64.30	43.19
Electricity, gas, water supply & other utility services	2.93	0.00	0.00
Construction	53.89	29.28	11.36
Trade, hotels, transport communication & services related to broadcasting	87.98	45.38	28.79
wholesale trade	49.61	38.13	9.51
transportation	23.92	57.22	55.62
accommodation	9.20	73.36	73.36
information	5.24	10.89	10.61
Financial, real estate & professional services	16.76	22.96	22.87
financial activity	5.39	0.26	0.00
real estate	1.10	33.30	33.30
professional activity	4.30	26.85	26.85
administrative	5.97	38.71	38.71
Public administration, defence and other services	48.71	36.35	36.35
public admin	7.98	0.00	0.00
education	18.32	25.52	25.52
human health	6.05	0.00	0.00
arts/entertainment	1.41	57.49	57.49
other services	9.42	74.45	74.45
act of hhs	5.51	94.36	94.36
act of extra	0.02	28.20	0.00

Source: Authors estimation using PLFS (2017-18)

Table 9: NCO-9 occupation wise workers at risk of job loss

Occupation	Lockdown 1.0	Lockdown 2.0
legislator	1.6	1.9
professionals	2.2	2.8
technicians	2.9	3.8
clerks	1.3	1.7
service workers	22.0	17.5
skilled agriculture	0.4	0.4
craft	32.1	32.7
machine operator	16.7	21.1
elementary occupations	20.6	18.1

Source: Authors estimation using PLFS (2017-18)

3.4 Wage loss estimations

According to marginal productivity theory of wages, under perfect competition wages of workers are value of the marginal product of labour. If a worker is unable to supply his/ her labour then the value of the marginal product would be zero and so would the wages be. In the current COVID-19 pandemic scenario a worker who is unable to work from home (due to low RLI), would not add any value to the output and can be denied wages or given wage cuts depending on the employment contract. Moreover, if the supply shock is not transitory and persists for a while they could lose their job as well. The halt in major part of the economy, due to lockdown measures, thus put workers at risk of job loss and a possible wage and income too. In this anticipation, the Government of India on March 29th 2020 ordered the mandatory payment of wages to alleviate suffering of those impacted (MHA, 2020a.7). But later, the Supreme Court overruled this order and said that the employers who are unable to pay full wages will not be prosecuted (Rautray, 2020). Given this backdrop, while estimating wage loss, we thus assume that employment of informal nature would have disruptions in regular payment of wages. To identify workers (wage earner) who will have a higher likelihood of wage disruptions we follow the paid leave criteria (so that we do not overestimate wage loss). Paid leave is one of the benefits, along with social security benefits which a worker with the formal employment contract gets. If a worker (wage earner) is not eligible for a paid leave then we assume that he/she is informally employed and do not receive wages due to labour supply disruptions. Therefore the workers who are at risk of job loss and are eligible for paid leave have been assumed to receive

wages and thus not considered for wage loss estimations.[38] We calculate the expected monthly wage loss estimation with job loss for Lockdown 1.0 at 2017-18 prices.

Table 10: Expected monthly wage loss (at 2017-18 prices) due to lockdown measures

Wage quartiles	Regular and salaried employee				Casual worker				Total monthly wage loss (Rs crores)
	Average RLI	Risk of losing job (%)	Monthly wage loss		Average RLI	Risk of losing job (%)	Monthly wage loss		
			(%)	Rs (in crores)			(%)	Rs (in crores)	
Quartile 1	0.20	55.0	44.5	5429.43	0.08	15.9	16.3	1094.39	6523.82
Quartile 2	0.20	54.0	40.2	7149.42	0.06	18.7	18.6	2429.96	9579.38
Quartile 3	0.30	41.8	22.9	7258.78	0.04	24.0	23.8	3128.30	10387.08
Quartile 4	0.48	19.3	3.1	2131.92	0.03	29.7	29.4	5165.18	7297.10
Total	0.29	43.5	16.8	21969.55	0.06	21.2	23.4	11817.83	33787.39

Source: Authors estimation using PLFS 2017-18

Table 10 shows the expected monthly wage loss estimates for both regular and salaried employee and casual workers.[39] According to our estimations total monthly wage loss due to lockdown measures is Rs 33.8 thousand crores. In proportional terms, this is 23.4 percent and 16.8 reductions in the total wage earnings for casual workers and regular and salaried wage employee. Interestingly, for regular and salaried employees the proportion of workers who are at risk of losing jobs, as well as the proportion of monthly wage loss, decreases with increasing wage quartiles. In other words, those with lower wages (lower quartiles) have a higher risk of job loss and more wage loss due to lower RLI, which makes them most vulnerable. That is consistent with the findings of Adams-Prassl et al. (2020) who surveyed both UK and US citizens in March 2020 to identify that higher wage occupation workers are able to work more from home. However, we find no such evidence for casual workers whose RLI scores are low across all wage quartiles. This shows the vulnerability of casual workers across wage quartiles to deal with the uncertain economic situation caused due to COVID-19 pandemic.

To understand the severity of wage loss due to labour supply shock let us do some thought experiment. If we assume these wage earners remain jobless for six months continuously, then the total wage loss would amount to Rs. 2 lakh crores. This amount is five times the annual union budget allotted for employment guarantee scheme MGNERGA in 2020-2021 (Union Budget,

[38] For a detailed methodology of wage loss estimation please refer to Appendix B.

[39] For wage loss estimations we only consider workers who are wage earners regular and salaried employee and casual workers.

2020). This large scale wage loss can dampen the effective demand in the Indian economy. From a macroeconomic perspective, the first order supply shock could fuel into second order demand shocks as millions might lose their wages and income. Therefore immediate steps are needed to address this situation. Perhaps, provision of social security net comprises of the minimum wage guarantee and/or an employment guarantee scheme is important in this context.

3.5 GVA loss estimations

In this section, we predict the loss in GVA (at 2011-12 prices) due to labour supply shock in the first four lockdowns.[40] Additionally, we estimate the growth rate in GVA in the first quarter of 2020-2021 as a percentage change over the previous year. The estimates of GVA loss presented here are based only on first order supply shock. However, in the medium run, the actual losses could be higher as the output will subsequently be affected by second order supply shocks and demand shocks. Assuming that the effects of first order supply shock will dominate initially, we provide GVA loss predictions over a very short period from 25th March 2020 to 31st May 2020 and GVA growth predictions for Q1:2020-21.[41]

To estimate the loss in GVA in Lockdown 3.0 and Lockdown 4.0 we assume that the labour supply shock in Lockdown 2.0 persisted in these periods too. This assumption is motivated by the OxCGRT "COVID-19: Government Response Stringency Index", according to which, in terms of stringency measures, India was still among the top ranked countries on 31st May 2020. However, we acknowledge that the labour supply shock would have been marginally lower in the Lockdown 3.0 and Lockdown 4.0 than Lockdown 2.0 given the stringency index was reduced from 96.3 on 4th May to 79.17 on 31st May. Therefore our GVA loss figures for Lockdown 3.0 and Lockdown 4.0 tend to be slightly biased upward.

Table 11 shows the industrial group wise loss in GVA at basic prices (at 2011-12 prices) for the first four lockdown periods for the baseline model. As covered in Section 2.2, the baseline model assumes that the labour and capital are imperfect substitutes with output following a Cobb-Douglas production function. Our estimations show that due to the aggregate labour supply shock there has been a GVA loss (at 2011-12 prices) of Rs.3.35 lakh crores during four

[40] All GVA loss estimations are at basic prices (at 2011-12 prices)
[41] In the initial periods, the second order supply and demand linkages might be levelled off with the presence of inventories in firms and savings with the consumers.

lockdown periods. That is about 13 percent reduction in GVA (at 2011-12 prices) from a no COVID-19 scenario.

The most impacted industrial groups are *Trade, hotels, transport communication & services related to broadcasting*, *Public administration, and defence and other services* and *Manufacturing*. These three major industrial groups account for 72.5 percent of the total GVA loss in the economy (at 2011-12 prices). Within these three major industrial groups, *Trade, hotels, transport communication & services related to broadcasting* are affected the most, with GVA loss percentage of 21.35 followed by *Public administration, defence and other services* and *Manufacturing* with 19.62 percent loss and *Manufacturing* with 16.10 percent loss.

Although, the *Manufacturing* has low RLI and a higher share of non-essential industry in Lockdown 1.0 than the other two sectors, the GVA loss during lockdown is higher for *Trade, hotels, transport communication & services related to broadcasting* and *Public administration, defence and other services* and *manufacturing*. This is due to the following reasons, firstly according to KLEMS data the labour income share, α, in manufacturing industrial group is 0.32, which is lower than the labour income share of 0.49 and 0.68 in *Trade, hotels, transport communication & services related to broadcasting* and *Public administration, defence and other services* and *manufacturing.*[42] Secondly, the share of the non-essential industry for *Public administration, defence and other services* stayed at 70.37 percent in both the Lockdown 1.0 and Lockdown 2.0, whereas for manufacturing it reduced from 83.39 percent in Lockdown 1.0 to 54.19 percent in the Lockdown 2.0 (Table 8). The perceptible decline in the share of the non-essential industry for manufacturing in Lockdown 2.0 resulted in a relatively lower loss in GVA than *Public administration, defence and other services* even during Lockdown 3.0 and Lockdown 4.0.

According to CBO (2006) the severely impacted industries from the first order demand shock in a pandemic, like 1918-1919 Spanish flu outbreak, are likely to be arts and recreation, accommodation and transportation (rail, air, transit). Note that these industries are sub-industries within the broad industrial groups: *Trade, hotels, transport communication & services related to broadcasting* and *Public administration, defence and other services*. As discussed above, these

[42] The KLEMS database provides data on labour share income for the disaggregated manufacturing sector. Due to data unavailability of quarterly GVA series, we use a simple average at an aggregated level.

are also the most affected industries with highest GVA losses from first order supply shocks. Therefore it is likely that the GVA losses for these industries will sustain as the demand for their output will remain low even if the supply recovers.

Table 11: GVA loss at basic prices (2011-12 prices) by industry

Industry	Gross Value Added at Basic prices (at 2011-12 prices) loss (Rs. Crores) (Percentage loss due to lockdown (%))				
	Lockdown 1.0	**Lockdown 2.0**	**Lockdown 3.0**	**Lockdown 4.0**	**All periods**
Agriculture, forestry & fishing	22.62 (0.02)	7.87 (0.01)	5.67 (0.01)	5.55 (0.01)	41.71 (0.01)
Mining & quarrying	1372.00 (5.64)	255.75 (1.22)	182.64 (1.22)	177.16 (1.22)	1987.55 (2.65)
Manufacturing	28344.51 (20.78)	16875.58 (13.96)	12356.19 (13.96)	12306.28 (13.96)	69882.57 (16.10)
Electricity, gas, water supply & other utility services	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)
Construction	13679.36 (22.48)	4743.40 (8.72)	3460.40 (8.72)	3427.03 (8.72)	25310.19 (13.03)
Trade, hotels, transport communication & services related to broadcasting	37217.14 (23.79)	27878.74 (20.22)	20318.83 (20.22)	20149.02 (20.22)	105563.73 (21.35)
Financial, real estate & professional services	18589.24 (10.69)	18197.97 (10.66)	13891.34 (10.66)	14227.30 (10.66)	64905.85 (10.67)
Public administration, defence and other services	21052.45 (19.65)	18684.54 (19.61)	13765.91 (19.61)	13815.62 (19.61)	67318.52 (19.62)
Total	120277.31 (15.15)	86643.86 (12.03)	63980.98 (12.04)	64107.96 (12.07)	335010.11 (13.00)

Source: Authors estimation

Further, we simulate a scenario (Model 2) with perfect complementarity between capital and labour in the manufacturing industry, such that the fall in labour supply would lead to a proportional fall in output. The objective of simulating this case is to see the loss to GVA in manufacturing sector under the extreme setting of perfect input complementarity. Table 12 shows the loss in GVA at basic prices (at 2011-12 prices) estimated from Model 2. As expected the loss in GVA for *Manufacturing* has increased from 16.10 percent to 49.82 percent. Since we do not consider the presence of supply linkages between the industries, the GVA loss in other industries does not change. Overall in comparison to the baseline model, the GVA loss estimated

from Model 2 increases to Rs. 4.8 lakh crores which is 18.68 percent fall from a no COVID-19 scenario.

Table 12: GVA loss at basic prices (2011-12 prices) in manufacturing industry for Model 2

Industry	Gross Value Added at Basic prices (at 2011-12 prices) loss (Rs. Crores)				
	Percentage loss due to lockdown (%)				
	Lockdown 1.0	Lockdown 2.0	Lockdown 3.0	Lockdown 4.0	All Phases
Manufacturing	87688.62	52207.53	38226.02	38071.60	216193.77
	64.30	43.19	43.19	43.19	49.82
GVA	179621.42	121975.81	89850.80	89873.28	481321.32
	22.63	16.93	16.91	16.92	18.68

Source: Authors estimation

Table 13 shows estimates for year on year (y-o-y) quarterly growth rates in GVA at basic prices (2011-12 prices) after subsuming labour supply shock in the present COVID-19 pandemic. As the period covered in the baseline model and Model 2 is from 25th March 2020 to 31st May 2020, to estimate y-o-y quarterly estimate for April-June, we present three scenarios. In Scenario 1 the economy returns to normal at the end of Lockdown 4.0 i.e. on 1st June 2020. In Scenario 2 the economy returns to normal on 15th June 2020, and in Scenario 3 the economy does not return to normal till 30th June 2020. To simulate Scenario 2 and Scenario 3, we assume that the labour supply shock at the end of Lockdown 4.0 persists till 15th June and 30th June, respectively.

Table 13: Forecasted estimates of GVA growth at basic prices (2011-12 prices) for Q1:2020-2021 (April 2020-June 2020)

	Description	Forecasted GVA growth for 2020-2021:Q1	
		Percentage change over previous year	
		Baseline Model	Model 2
Scenario 1	Economy normalizes on 1st June 2020	-4.64	-8.45
Scenario 2	Economy normalizes on 15th June 2020	-6.72	-11.36
Scenario 3	Economy does not normalize till 30th June 2020	-8.80	-14.28

Source: Authors estimation

In the best case scenario, Scenario 1, the economy contracts by 4.64 percent and by 8.45 percent in the first quarter of 2020-2021 using baseline model and Model 2, respectively. The economy contracts further in case of Scenario 2 under both model simulations by 6.72 percent and 11.36 percent, respectively. In the worst case scenario, Scenario 3, when the labour supply shock persists until the end of June, the contraction to the economy will be in a range of 8.8 percent to 14.28 percent.

4. Conclusion

This paper carries out a quantitative assessment of the impact of COVID-19 pandemic on the Indian economy. COVID-19 pandemic has affected economies throughout the world. According to the World Bank forecasts global GDP in 2020 would contract by 5.2 percent (World Bank, 2020). Despite imposing the most stringent lockdown, India has not been able to contain the spread of the virus and has the fourth highest number of confirmed COVID-19 cases in the world as on 15th June 2020. OECD has predicted that the GDP in India would contract by 20 percent due to the lockdown measures (OECD, 2020).

We analyze the first order supply shock to the Indian economy through labour supply reductions. Our estimates show that Lockdown 1.0 and Lockdown 2.0 have put around 116 million and 79 million workers at risk of job loss, respectively. The wage earners among the workers at risk of job loss are expected to have monthly wage loss amounting to Rs 33.8 thousand crores (2017-18 prices). Assuming they remain jobless for a continuous six months, the total expected wage loss amounts to Rs. 2 lakh crores, which is five times the budget allotted for employment guarantee scheme MGNREGA in 2020-2021. Additionally, the labour supply reductions to the Indian economy, associated with the lockdown measures, are predicted to bring immediate GVA loss (at 2011-12 prices) between 13 percent and 19 percent. The y-o-y quarterly growth rate forecast of GVA (at 2011-12 prices) for Q1:2020-21 is expected between -4.6 percent and -8.8 percent, using the baseline model. Based on our analysis and scenario predictions, following are the crucial issues which we think a policymaker needs to keep in mind;

1. We find that majority of workers who are at risk of job loss are in the states with the highest number of COVID-19 infections. For instance, 40 percent and 70 percent of workers at risk of job loss are in the top 5 and the top 10 states with the maximum number of COVID-19 infections, respectively. This implies that in Lockdown 1.0 about 81.2 million workers at risk of job loss belong to the top 10 states with the maximum number of COVID-19 infections. Given that these states will continue to follow strict social distancing measures, till the epidemic curve is flattened, the labour supply disruptions would persist and more workers would be rendered jobless.

2. According to our estimates for Lockdown 1.0, out of 116 million workers who are at risk of losing jobs, 104 million workers are informally employed. Disaggregating further, we find that 79 million workers are informally employed in the unorganized sector and are at the highest risk of job loss. Wide social security net and continuous state support are needed in the form of minimum wage guarantee and employment guarantee schemes to alleviate the hardships for millions of these workers.

3. We find that in service industries like transport (air and rail), art & entertainment and accommodation, 57.22 percent, 57.49 percent and 73.36 percent workers are at risk of job loss, respectively. Given that the demand for these services will also remain low (due to high risk of infection exposure) till the pandemic abates, the output in these industries will remain low even if the supply resumes. In this anticipation, layoffs in these service industries are expected to be high.

The predictions we provide in the present paper for the immediate short-run can largely be captured through the first order supply shock. However, as the pandemic spreads its effect on the second order demand (wage/income loss) and supply shocks (supply chain linkages) would gradually dominate. In the worst case scenario, the job losses leading to a fall in the aggregate demand could bring further job losses leading to a further fall in demand. Guerrieri et al. (2020) show that the losses in the aggregate demand due to initial supply shock could be larger than the shock itself. Thus, the domestic demand must be sustained either through fiscal or other liquidity enhancing means. Given that the fiscal space is already constraint, Goyal (2020) suggests a credit-led growth post-COVID scenario.

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Appendix A

Measuring informal employment in India

Under international Standards according to the 17th ICLS, informal employment combines all informal jobs found in the Informal Sector or Households, plus informal jobs carried out in the Formal Sector. Households employing paid domestic workers are excluded from informal sector enterprises and treated separately as part of a category named "households" (15th ICLS). While own-account workers and employers can hardly be separated from the type of enterprise they own. Thus, the informal nature of their jobs follows directly from the characteristics of the enterprise. In other words, these categories of jobs are informal if the nature of the enterprise belongs to the informal sector. Contributing family workers are considered informal employment irrespective of the sector they belong to. It is only employees that may have formal or informal jobs if the employment relationship is, in law or practice, not subject to national labour legislation, income taxation, social protection or entitlement to certain employment benefits. Other considerations are given to members of informal producers' cooperatives. Similar to own-account and employers their jobs follows directly from the characteristics of the cooperative they belong to. Finally, those own-account engaged in the production of goods exclusively for own final use by their household, such as subsistence farming, construction of own dwellings, manufacture of wearing apparel, furniture, water and fuel collection, etc., if considered employed according to the 13th ICLS definition of employment (ILO, 1982).

Furthermore, the ILO definition of informal sector suggests that the threshold number of employees in the definition should be decided as per national circumstances. Specification of the employment size limit of the enterprise in the national definition of the informal sector is left to the country's discretion. For international reporting, however, countries should provide figures separately for enterprises with fewer than five employees.

In India, the National Commission for Enterprises in the Unorganised Sector (NCEUS) found appropriate to set a threshold in addition to the ownership criteria for defining the informal sector. It took a 10-worker threshold, noting that labour and social security legislation applies mainly to enterprises with ten or more. NCEUS defines the informal sector comprised of "all unincorporated enterprises owned by individuals or households engaged in the sale and

production of goods and services operated on a proprietary or partnership basis and with less ten workers.

NCEUS is aligned to the ICLS and ILO definitions in the following issues.-

- Self-employed own-account workers in the informal sector or private households, and self-employed employers the informal sector – do not enjoy JOB security or SOCIAL security and are considered as informal employment as per the conceptual framework of the ILO.

- Unpaid family workers, whether in the informal or formal sector, are invariably regarded as informal employment.

- Paid employees can be informal or formal employment depending on the availability of both job security and social security.

- Casual based workers, irrespective of the informal or formal sector where they are employed they are considered without job security and social security.

We take a similar approach for estimating the different categories of informal employment both in the formal and informal sector. However, in classifying economic units in the formal sector we include all Government/public sector, public/private incorporated companies; co-operatives and trusts. We also classify the following enterprise as organized if the number of workers is 10 or above - Proprietary (male and female); and partnership with members from the same household or members from different households; and employer's households. Other types of enterprises are classified in the formal sector if they employ ten or more workers. For those enterprises in the Agriculture sector with no definition on the type of enterprise and number of workers, we turn to identify if they provide social benefits to its workers, if this is the case we classify them in the formal sector. If there is no response on the social security benefits, by exclusion we classify them in the informal sector. We have used provident fund (PF) as the criteria for classifying workers employment as formal and informal Abraham, R. (2016). If a worker is receiving at least PF, then he/she is classified as formally employed and vice versa.

In order to capture the dimensions of informality at enterprise level and worker level, we make use of the following classifications:

1. Formal employment in organized sector (FOS)
2. Informal employment in organized sector (IOS)
3. Formal employment in organized sector (FUS)
4. Informal employment in unorganized sector (IUS)
5. Formal Employer's household (FEH)
6. Informal Employer's household (IEH)

Appendix B

Wage loss estimation

In this paper, we have estimated the wage loss for regular and salaried employees and casual workers. We have used Periodic Labour Force Survey (PLFS) 2017-18 for this purpose. The information on wages in PLFS is given at the current weekly activity status (CWS) for regular and salaried employees and casual workers. The information on earnings for regular and salaried employees is available for the preceding calendar month. However, for casual worker wage earnings was recorded for each of the day of the reference week (last 7 days preceding the date of the survey) when the household member had worked as casual labour.[43]

To estimate the workers at risk of losing jobs due to the lockdown measures taken by the government we have made use of both usual principal and subsidiary status of an individual *(usual status (ps+ss)).* However, the information on earning is available at CWS. Therefore for estimating wage loss we have identified those individuals whose usual status (ps + ss) matches with current weekly status for regular and salaried employees and casual workers. We assume that if for a specific individual usual activity status (ps + ss) matches with current weekly activity status, then that individual average earning approximate his/her average usual earnings.

Using this criterion for identification we find that 99.3 percent of the individuals whose usual activity status (ps + ss) is regular and salaried employee matches with their CWS. However, for casual workers, we managed to match 90.7 percent of individuals. For wage loss estimations we have not considered those individuals whose usual activity status (ps + ss) does not match with CWS.

[43] Annual Report PLFS 2017-18

Further, for wage loss estimations we have considered '*month*' as a unit of time. As given above the wages for regular and salaried employees are already available at the level of the month. However, the wages of casual worker are converted into monthly wages by using the following formula:

*monthly wages of casual worker = (weekly earning of casual worker*52)/12*

To estimate the wage loss, we adjusted the weighted representation of the worker in the population using RLI and essential and non-essential categorisation, as we did to arrive at labour supply shock for a specific occupation within an industry. However, in the case of wage loss estimation, the adjustment is not done for an individual who is eligible for paid leave. Thus the new weighted sum of wages for a particular category of workers provides us with the share of wages after adjusting for the labour loss and the eligibility of paid leave. Using this criterion separate estimations have been carried out for regular and salaried employees and casual workers.

Appendix C

Baseline model for GVA (at 2011-12 prices) estimation

Assuming a particular sector/ industry i in an economy follows a Cobb-Douglas production function in the Baseline Model:

$$Y_i = A_i f(L_i, K_i)$$

where $f(L_i, K_i) = L_i^{\alpha_i} K_i^{(1-\alpha_i)}$. Y_i is the industry level output, A_i is the industry specific total factor productivity, $0 < \alpha_i < 1$ is the industry specific labour income share in output, L_i and K_i are labour and capital inputs to production respectively. In a competitive setting, the industry would choose L_i and K_i to maximize the profit,

$$\pi_i = Y_i P_i - w_i L_i - R_i K_i$$

where P_i, w_i and R_i are output price, wages and interest rates, respectively. This maximization would give us the following relation between real wages and the marginal product of labour, MPL_i

$$MPL_i = \frac{w_i}{P_i}$$

where $MPL_i = \alpha_i \frac{Y_i}{L_i}$. The total output loss for an industry i due to labour loss occurred during the lockdown period in COVID-19 is calculated as follows,

$$\Delta Y_{i,t} = MPL_{i,t} \times \Delta L_{i,t} \qquad \text{Eq. 6}$$

Here $\Delta Y_{i,t}$ and $\Delta L_{i,t}$ are the total output loss and labour supply shock for an industry i in time period t, respectively. Substituting $MPL_{i,t}$ from above, we get

$$\Delta Y_{i,t} = \alpha_{i,t} \frac{Y_{i,t}}{L_{i,t}} \times \Delta L_{i,t}$$

Re-arranging above expression we get the following,

$$\Delta Y_{i,t} = \alpha_{i,t} \times \frac{\Delta L_{i,t}}{L_{i,t}} \times Y_{i,t}$$

The time period $t = 1, 2, 3, 4$ refers to the period of lockdown period from 25th March to 31st May 2020, namely: Lockdown 1.0, 2.0 3.0 and 4.0, respectively. The expression, $\alpha_{i,t} \times \frac{\Delta L_{i,t}}{L_{i,t}}$ in thus represents the rate of output loss during the lockdown period. Note that when labour loss approaches total labour input, the output lost would be labour share of the total output, i.e. $\lim_{\Delta L_{i,t} \to L_{i,t},} \Delta Y_{i,t} = \alpha_{i,t} \times Y_{i,t}$. If the capital and labour were to be perfect complements and output follows a Leontief production function, such that

$$f(L_i, K_i) = \min\{K_i, L_i\}$$

This implies $Y_i = \min\{A_i K_i,\ A_i L_i\}$, such that that 1 unit of capital requires 1 unit of labour to produce A_i units of output for industry i. When the economy is at equilibrium and labour supply shock occurs, output loss $\Delta Y_i = A_i \Delta L_i$. Re-writing this, we get $\frac{\Delta Y_{i,t}}{Y_{i,t}} = \frac{\Delta L_{i,t}}{L_{i,t}}$. On impact, with labour supply shock, the output will follow a production function $Y_i = A_i L_i$, which is a special case of the Baseline model with $\boldsymbol{\alpha_i} = 1$. Thus to simulate a case for perfect complements in production inputs we assume $\boldsymbol{\alpha_i} = 1$. The output loss here would be as follows,

$$\Delta Y_{i,t} = \frac{Y_{i,t}}{L_{i,t}} \times \Delta L_{i,t}$$

Since, $\boldsymbol{\alpha_{i,t}} \in (0,1)$ in the Benchmark Model and $\boldsymbol{\alpha_{i,t}} = 1$ with complementary capital and labour, the output loss would be higher in the latter.

ARIMA Model for real GVA (at 2011-12 prices) forecasts

We use ARIMA modelling to forecast sector wise Gross Value Added for Q1:2020-2021. To do this we follow Box-Jenkins method to fit an ARIMA model to each quarterly series on major economic activities. We check for unit root as a test for stationarity using Augmented Dickey Fuller (ADF) test before fitting a model. The ARIMA model fitted on each of the series is summarized as follows:

Sector	Fitted Model
Agriculture, forestry & fishing	ARIMA $(0,1,0) \times (0,1,2)_4$
Mining & quarrying	ARIMA $(0,1,1) \times (0,1,0)_4$
Manufacturing	ARIMA $(0,1,1) \times (0,1,1)_4$
Electricity, gas, water supply & other utility services	ARIMA $(0,1,1) \times (0,1,1)_4$
Construction	ARIMA $(0,1,0) \times (0,1,2)_4$
Trade, hotels, transport communication & services related to broadcasting	ARIMA $(2,1,0) \times (0,1,0)_4$
Financial, real estate & professional services	ARIMA $(3,1,0) \times (0,1,1)_4$
Public administration, defence and other services	ARIMA $(0,1,1) \times (0,1,0)_4$

Source: Authors estimation

The sum of all the above broad industry level forecasted series at a given time t would give us GVA at basic prices (at 2011-12 prices).

Appendix D

RLI for Occupations – At NCO 3- Digit level

NCO 2004 Occupation Codes	Description	Remote Labour Index
815	Chemical- Processing- Plant Operators	0
712	Building Frame and Related Trades Workers	0
514	Other Personal Services Workers	0
814	Wood Processing and Paper Making Plant Operators	0
711	Miners, Shot -Firers, Stone Cutters and Carvers	0
722	Blacksmiths, Tool Makers and Related Trades Workers	0
933	Transport Labourers and Freight Handlers	0
827	Food and Related Products Machine Operators	0
713	Building Finishers and Related Trades Workers	0
832	Motor Vehicle Drivers	0
513	Personal Care and Related Workers	0
323	Nursing and Midwifery Associate Professionals	0
817	Automated Assembly Line and Industrial Robot Operators	0
613	Market- Oriented Crop and Animal Producers	0
744	Pelt, Leather and Shoe Making Trades Workers	0
824	Wood Products Machine Operators	0
823	Rubber and Plastic Products Machine Operators	0
512	House Keeping and Restaurant Services Workers	0
811	Mining and Mineral Processing Plant Operators	0
916	Garbage Collectors and Related Labourers	0
314	Ship and Aircraft Controllers and Technicians	0
714	Painters, Building Structure Cleaners and Related Trades Workers	0
614	Forestry and Related Workers	0
523	Stall and Market Salespersons	0
931	Mining and Construction Labourers	0
611	Market Gardners & Crop Growers	0
816	Power Production and Related Plant Operators	0
911	Street Vendors and Related Workers	0
615	Fishery Workers, Hunters and Trappers	0
831	Locomotive Engine Drivers and Related Workers	0
724	Electrical and Electronic Equipment Mechanics and Fitters	0
913	Domestic and Related Helpers, Cleaners and Launderers	0
915	Messengers, Porters, Door Keepers and Related Workers	0
826	Textile, Fur and Leather Products Machine Operators	0
812	Metal Processing and Plant Operators	0

NCO 2004 Occupation Codes	Description	Remote Labour Index
822	Chemical Products Machine Operators	0
912	Shoe Cleaning and Other Street Services Elementary Occupations	0
828	Assemblers	0
813	Glass, Ceramics and Related Plant Operators	0
516	Protective Services Workers	0
833	Agricultural and Other Mobile Plant Operators	0
821	Metal and Mineral Products Machine Operators	0
723	Machinery Mechanics and Fitters	0
612	Market Oriented Animal Producers and Related Workers	0
347	Artistic, Entertainment and Sports Associate Professionals	0.0625
522	Shop Salespersons and Demonstrators	0.0625
742	Wood Treaters, Cabinet Makers and Related Trades	0.0625
223	Nursing Professionals	0.0625
741	Food Processing and Related Trades Workers	0.08333
932	Manufacturing Labourers	0.125
322	Modern Health Associate Professionals (Except Nursing)	0.125
920	Agricultural, Fishery and Related Labourers	0.125
346	Social Work Associate Professionals	0.125
829	Other Machine Operators and Assemblers	0.125
721	Metal Moulders, Welders, Sheet Metal Workers, Structural Metal Preparers and Related	0.125
914	Building Caretakers, Window and Related Cleaners	0.125
825	Printing, Binding and Paper Products Machine Operators	0.125
743	Textile, Garment and Related Trades Workers	0.125
734	Printing and Related Trades Workers	0.125
511	Travel Attendants, Guides and Related Workers	0.25
731	Precision Workers in Metal and Related Materials	0.25
834	Ships Deck Crews and Related Workers	0.25
243	Archivists, Librarians and Related Information Professionals	0.25
732	Potters, Glass Makers and Related Trades Workers	0.25
344	Customs, Tax and Related Govt. Associate Professionals	0.25
315	Safety and Quality Inspectors	0.25
521	Fashion and Other Models	0.25
620	Subsistence Agricultural and Fishery Workers	0.25
421	Cashiers, Tellers and Related Clerks	0.25
221	Life Science Professionals	0.25
733	Handicraft Workers in Wood, Textile, Leather and Related Materials	0.375
222	Health Professionals (except nursing)	0.375
313	Optical and Electronic Equipment Operators	0.4375

NCO 2004 Occupation Codes	Description	Remote Labour Index
123	Other Department Managers	0.4375
122	Production and Operations Department Managers	0.4375
214	Architects, Engineers and Related Professionals	0.4375
112	Administrative & Executive Officials	0.5
130	General Managers	0.5
348	Religious Associate Professionals	0.5
419	Other Office Clerks	0.5
414	Library, Mail and Related Clerks	0.5
333	Special Education Teaching Associate Professionals	0.5
413	Material Recording and Transport Clerks	0.5
324	Traditional Medicine Practitioners and Faith Healers	0.5
113	Traditional Chiefs and Heads of Villages	0.5
345	Police Inspectors and Detectives	0.5
321	Life Science Technicians and Related Health Associate Professionals	0.5
246	Religious Professionals	0.5625
242	Legal Professionals	0.5625
311	Physical and Engineering Science Technicians	0.5625
111	Legislators	0.583333
343	Administrative Associate Professionals	0.625
341	Finance and Sales Associate Professionals	0.666667
342	Business Services Agents and Trade Brokers	0.75
332	Pre-Primary Education Teaching Associate Professionals	0.75
114	Senior Officials of Special- Interest Organisations.	0.75
412	Numerical Clerks	0.75
515	Astrologers, Fortune- Tellers and Related Workers	0.75
334	Other Teaching Associate Professionals	0.75
241	Business Professionals	0.791667
211	Physicists, Chemists and Related Professionals	0.875
411	Secretaries and Key Board- Operating Clerks	0.875
232	Secondary Education Teaching Professionals	0.875
331	Middle & Primary Education Teaching Associate Professionals	0.875
233	Other Teaching Professionals	0.875
231	College, University and Higher Education Teaching Professionals	0.9375
312	Computer Associate Professionals	1
121	Directors and Chief Executives	1
422	Client Information Clerks	1
212	Mathematicians, Statisticians and Related Professionals	1
245	Writers and Creative or Performing Artists.	1

NCO 2004 Occupation Codes	Description	Remote Labour Index
244	Social Science and Related Professionals	1
213	Computing Professionals	1

Source: Authors estimation