Title: Food Security and Human Mobility During the COVID-19 Lockdown

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Abstract:

During the COVID-19 crisis, millions of migrants around the world face food insecurity. This could force migrants to travel during the pandemic, exposing them to health risks and accelerating the spread of the virus. Anecdotal evidence demonstrates the importance of enforcing food security policies to tide the crisis. However, the effects of these policies on containing mobility during the crisis remain unknown. Using mobility data from Facebook, we demonstrate that a policy to guarantee food security that has attracted attention from the Supreme Court of India— portable ration cards—is related to lower mobility during India's COVID-19 lockdown. *Intra-state* portable ration cards, which give migrants access to food when they move within their state, are associated with 12% lower intra-state mobility. This effect is particularly strong for states that have fully implemented the policy compared to states that have partially implemented it. However, *inter-state* portability of ration cards is not related to reduced inter-state mobility, suggesting frictions in implementing the policy across state borders. We also find that food distribution activities by ration shops and civil society actors at the local level are associated with reduced mobility both within states and across state borders. Our study provides generalizable lessons for policymakers around the world: food security policies are essential for helping migrants restrict their travel during the pandemic. Policy implementation requires lead time; therefore, central governments need to coordinate with local actors to increase food distribution to migrants in the immediate term.

Main Text:

During the COVID-19 crisis, policy makers across the world are faced with the dual objectives of ensuring that citizens obey lockdown orders, but also have access to food (SI Table S1 provides examples of current food security issues in various countries, including Colombia, Greece, India, Malaysia, Nigeria, Singapore, South Africa, and the United States). In India, food security has been of particular concern for migrants, as they are constrained by

a lack of family and caste-based social networks in their host locations (1–3). Workers who leave their hometowns also lack access to subsidized food made available through the public distribution system, i.e., ration shops. This is because ration cards, which grant access to subsidized food for citizens, have historically not been portable either within the state or across state borders – in other words, a ration card till recently could not be used to procure subsidized food outside the card holder's hometown (4). A recent survey in India reveals a crisis of starvation, with 72% of the surveyed migrants indicating that their existing food rations would deplete in two days (5). Additionally, migrants who have limited income may be forced to travel back home to access food. Such mobility may not only increase the health risk faced by migrants, but may also accelerate the spread of the virus (6, 7). Similar concerns have been echoed around the world (8–10).

We study the effects of a pre-COVID-19 policy instrument—i.e., portable ration cards targeted at delivering food security to migrants—on human mobility during the lockdown in India. India's ration card system is similar to China's long-standing *hukou* system in the sense that both systems make it difficult for migrants to access key resources in their host locations. We exploit variation in implementation of this policy across India (28 states and 8 union territories) and the fact that ration cards were portable with respect to some states but not others. Specifically, at the start of the lockdown, intra-state portability of ration cards was available in 18 states (13 states that have fully implemented the policy and five states with partial implementation), and inter-state portability was available within a single cluster of 12 states (11). All 12 states with inter-state portability have also adopted intra-state portability. Intra-state portability of ration cards allows migrants to procure food when they move from their home locations to host locations within their home states. In contrast, inter-state portability of ration cards allows migrants to procure food at ration shops outside their home states. States' adoptions of portability policies were not correlated with the historic number of

migrants in different states, as measured by the 2008 National Sample Survey (correlation = 0.17). In India, about 88% of the internal migrants are intra-state migrants and 12% are inter-state migrants (12).

We use a difference-in-differences specification to compare mobility patterns in portable states to that in non-portable states, before and after the lockdown. Controlling for relevant observables, we document 12% lower *intra-state mobility* in states where one's ration card had *intra-state portability* (i.e., it can be used across subdistricts in one's home state), compared to states where one's ration card did not have intra-state portability (i.e., it can be used only at the local ration shop in one's home subdistrict). Since portability policies were not adopted by states randomly, we cannot rule out the possibility of a spurious relationship between the adoption of portability and mobility changes in the study period. To mitigate this concern, we use coarsened exact matching to match on past movement and historic migration population and find 14% lower intra-state mobility in states where the intra-state portability policy had been implemented.

We also find that the effect of inter-state portability of ration cards on inter-state mobility is insignificant. These results paint a contrasting picture: on the one hand, portability of ration cards within a given state was an important policy tool for ensuring intra-state migrants had food security and were able to adhere to the lockdown restrictions. On the other hand, the null results related to inter-state portability of ration cards suggest mounting difficulties in the implementation of the policy across state borders. The Indian Food Ministry's latest data lends support to our findings: in April 2020, only 0.002% of subsidized rations were procured by inter-state migrants at their host locations, whereas over 6% of subsidized rations were procured by intra-state migrants at their host locations (13).

We also exploit variation in the timing of portability implementation to document that the effect of intra-state portability on curbing intra-state mobility is significantly more

pronounced for states that have fully implemented the policy, as compared to states that had adopted the policy more recently and have achieved only partial implementation. This result suggests that, in order to maximize the benefit of this policy, there must be complete implementation at the state level. There must also be enough lead time dedicated to the policy rollout, including for the installation of electronic point of sales (EPoS) systems at ration shops, the linking of these EPoS systems to migrants' biometric information, and to ensure migrants are aware of the new system and how to access it (11). Differences in lead time might also explain why intra-state portability was effective in containing mobility, while inter-state portability was not: while the former policy was launched in 2015, the latter policy was launched in 2019.

In other analysis, we find that food distribution activities by local ration shops and civil society actors (as estimated based on daily news reports) are associated with reductions in *both* intra-state and inter-state mobility. This result suggests that local food distribution is a critical complement to formal policies in ensuring food security for migrants during the crisis. The finding also highlights the broader role of civil society actors in developing countries, where they can provide crucial support beyond that provided by the state (13).

The COVID-19 crisis has highlighted the need to provide food security to migrants around the world. In India, the key policy to provide food security, i.e., ration card portability, has come under the national spotlight: on April 28 2020, the Supreme Court of India suggested that the Central Government implement the policy nationally without further delay (14). This study helps quantify the effects of two different types of ration card portability (intra-state and inter-state) on human mobility during lockdown. Our results suggest that while the formal policy of interest (i.e. portability of ration cards in India) was effective within state borders, it failed to help migrants reduce inter-state movements. Our results also suggest that food distribution by ration shops and civil society actors helped

reduce both intra-state and inter-state mobility. For India and other countries around the world, our results collectively suggest that while formal policy instruments to guarantee food security are critical, they may not be universally effective during the lockdown. Central governments should therefore focus on two equally important priorities: ensuring food security policies are implemented effectively and engaging with local governments and local stakeholders to distribute food to migrants in the immediate term.

India's Lockdown and Ration Card Portability

In a largely unexpected announcement at 8 p.m. on March 24, 2020, Prime Minister Narendra Modi announced that India would go into a 21-day lockdown to combat the spread of COVID-19. "Every state, every district, every lane, every village will be under lockdown," said the Prime Minister (15). Many of India's migrant workers, who number more than 100 million and represent over 20% of the country's workforce (16), were stranded far from home. As many of these migrant workers have minimal savings and limited access to social benefits, food security is a critical concern. Some migrant workers walked hundreds of miles back to their hometowns following the lockdown announcement (17).

India set up the Public Distribution System (PDS) in 1944 to deliver subsidized food to citizens. Using "ration cards," people may purchase food at their local ration shops (also known as "fair price shops") at subsidized rates. Today in India, there are about 230 million ration card holders and 534,000 ration shops, 88% of which are digitized and possess electronic point of sales (EPoS) machines (11). During the lockdown, ration card holders are allowed to purchase food at cheaper rates and/or receive free food distributed by the government (at least 5 kg of wheat or rice and 1 kg of legumes) (18).

Despite the existing food distribution measures, many citizens, especially migrant workers, were left without access to these benefits. This is because, historically, ration cards

could only be used in the card holder's hometown ration shop. In recent years, some states have made ration cards portable, allowing card holders to procure subsidized food at ration shops outside their hometowns. There are two types of portability (11). First, starting in 2015, some states allowed migrants to use their ration cards anywhere in that state. As of March 2020, 18 states adopted *intra-state portability* (13 states with full implementation and five states with partial implementation). Second, a cluster of 12 states implemented *inter-state portability* by allowing migrants to obtain rations anywhere in that cluster, if both their home state *and* host state were part of the cluster (see SI for detailed descriptions of India's ration card policies). All 12 states that adopted inter-state portability also adopted intra-state portability. Notably, the implementation of ration card portability policies in a given state is largely unrelated to the number of migrants in that state.

Overall, ration card portability can be viewed as an extension of the National Food Security Act of 2013, which states that food distribution is the joint responsibility of the Centre and States/Union Territories (11).[1] Recently, both academics and journalists have suggested that lack of food security could force millions of migrants to travel and be exposed to the virus, and argued that ration card portability should be extended nationwide to help more people adopt social-distancing measures during the lockdown (19, 20). The issue of food insecurity being an impediment to the enforcement of lockdowns is a global one, with countries such as Colombia, Greece, and Nigeria also facing the prospect of migrants stuck in their current locations without adequate food supplies (8–10).

Ration Card Portability and Mobility

[1] To quote the website of the Government of India's Department of Food and Public Distribution, "while the Centre is responsible for allocation of required foodgrains to States/UTs, transportation of foodgrains up to designated depots in each State/UT and providing central assistance to States/UTs for delivery of foodgrains from designated FCI godowns to the doorstep of the FPSs, the States/UTs are responsible for effective implementation of the Act, which inter-alia includes identification of eligible households, issuing ration cards to them, distribution of foodgrain entitlements to eligible households through fair price shops (FPS), issuance of licenses to Fair Price Shop dealers and their monitoring, setting up effective grievance redressal mechanisms and necessary strengthening of Targeted Public Distribution System (TPDS)." (Department of Food & Public Distribution, "Responsibilities Under NFSA," https://dfpd.gov.in/pds-runfsa.htm, accessed April 28, 2020).

We study the effects of two types of ration card portability on the mobility of citizens during India's COVID-19 lockdown. Our human mobility data is from the Facebook's Data for Good project (21). Facebook's Data for Good team provides us with access to the GeoInsights portal. This allows us to download mobility datasets generated by an open cohort of individuals who are Facebook users, have smart phones, and are providing information through the Facebook app by having location services enabled. Specifically, the mobility data are aggregated at the location-dyad-day level, containing the number of users moving from one Indian subdistrict to another on a given day. In India, the subdistrict is two administrative levels below the state (see SI for more information on the mobility data). One caveat about the data is that movements that involve fewer than ten people are not recorded by Facebook. The pre-period consists of March 19-21, 2020 (data on mobility was available from Facebook only starting March 19). The post-period consists of March 25-April 3, 2020. March 22-24 are omitted to avoid the confounding of the national curfew and period of great uncertainty (see Final Sample sub-section in SI for more detail).[2] In total, our sample contains 219,671 movement observations.

In terms of methodology, we use a difference-in-differences set-up to compare the post-lockdown change in the level of mobility in ration-card-portable states (for both intra- and inter-state portability) with that in non-portable states. This is estimated using a set of ordinary least square regressions using a logged dependent variable (number of people moving intra-state or inter-state) and an interaction term between the post-lockdown dummy variable and the intra-/inter-portability dummy variable. We also include the following set of control variables to account for observed heterogeneity at the state-level and the district-

[2] Movement during the pre-period is similar to ordinary movement that took place weeks prior to the lockdown. We determined this by comparing the pre-period movement to the Baseline Movement given by Facebook, which measures the average movement on the same day of the week as a given day for the seven weeks before that day. Additionally, we re-ran all our models using different day omissions (zero days omitted, only omitting one day, omitting two days); results remained similar.

level: the interaction terms between the post-lockdown dummy and state area, state population, average nightlight,[3] number of migrants and number of inter-state migrants in a given state, and number of ration cards. All regressions include starting subdistrict fixed effects and are clustered at the subdistrict-dyad level (SI Data and Methods section provides more detail on model specifications and variables). We also use coarsened exact matching, (the matching was based on baseline movement and historic migration patterns between subdistricts) to match sub-distruct dyads in the portable states to subdistrict-dyads on the non-portable states. This matching exercise helps us minimize the pre-lockdown differences in movement between the treated group (subdistrict-dyads in portable states) and the control group (subdistrict-dyads in non-portable states).

Intra-state portability:

We find that intra-state portability of ration cards is associated with 12% fewer people moving from one subdistrict to another within the same state (p=0.00) (Table 1, Model 2). Results using CEM reveal 14% lower intra-state mobility in states where the intra-state portability policy had been implemented (Table S4, Model 1). Figure 1 maps out the changes in daily average intra-state mobility in Indian states before and after the lockdown. Due to the lockdown, most states experienced decreases in intra-state mobility. However, patterns in states with intra-state portability stand in contrast to patterns elsewhere. Whereas fully portable states generally exhibited large reductions in intra-state movement (especially Gujarat, Karnataka, Maharashtra, and Punjab), non-portable and partially portable states show a much more mixed pattern, with heavily populated states including Bihar, Odisha, and West Bengal displaying relatively minor intra-state movement reductions. Overall, patterns displayed by the maps support the regression results.

[3] Nightlight is measured as the average radiance composite in a region during night time. The data is downloaded from the National Centers for Environmental Information (https://ngdc.noaa.gov/eog/viirs/download_dnb_composites.html).

The mobility-reducing effect of intra-state portability varies between states that have fully implemented the policy and states that have only partial implementation. We find that, whereas the states with full implementation saw 15% less intra-state mobility (p=0.00) relative to the non-portable states, the states with partial implementation only saw 8.3% relative mobility reduction (p=0.02) (Table 1, Model 3). A test of equality between the two coefficients rejects the null hypothesis that the two coefficients are equal (p=0.00). In other words, the states that have fully implemented the policy are about twice as effective at reducing migrant mobility during the lockdown as the states that are still implementing the policy.

The two sub-maps in Figure 1 break down the movement patterns in two states: Karnataka (fully portable) and Bihar (partially portable). Movement in Karnataka was reduced by a visibly greater extent than that in Bihar. Overall, these results suggest that the policy effects of intra-state ration card portability may not be immediate if implemented in additional states. Lead time and operational experience are needed, potentially due to the installation of the EPoS systems and biometric technologies, as well as the process of making migrants aware of the new policy and teaching them how to utilize the new systems.

Figure 3 displays the difference between the average intra-state movement in fully portable states and that in other states over time. A visible discontinuity occurred with the start of the lockdown: whereas fully portable states had consistently higher movement than other states before, the differences became close to zero or negative in the post-period. Additionally, a series of robustness tests (regressions using different fixed effects, different lockdown cut-offs and different omitted dates provide support for our main results (SI Table S6). We also employed supervised machine learning models) to provide additional evidence that full implementation of intrastate ration card portability was a valid predictor of movement between sub-districts (SI Figure S3).

Inter-state portability:

We repeat a similar set of analyses for inter-state portability. Inter-state portability of ration cards was launched under the "One nation, one ration card" project (11). Its aim is to allow migrants to access food rations across the country, allowing inter-state migrants to stay in their host states rather than having to travel home to secure food. However, we find that inter-state portability was not significantly associated with inter-state mobility changes in India after the lockdown ($p=0.78$) (SI Table S7 Panel B). In other words, states with inter-state portability of ration cards did not see reduced mobility among inter-state migrants, as compared to states without this policy. Figure 2 maps out the changes in inter-state movement across states. Relative to the intra-state map (Figure 1), the inter-state map is more mixed: some states without inter-state portability (e.g., Punjab, Uttar Pradesh) exhibited drastic reductions in inter-state movement, whereas some portable states (e.g., Andhra Pradesh, Gujarat, Telangana) showed only minor reductions or no change in inter-state movement. These results can be understood in light of the extremely low participation of inter-state migrants in the program: according to data from the Food Ministry of India, only 200 inter-state migrants retrieved food at their host locations in April 2020 using inter-state portable ration cards, compared to 650,000 intra-state migrants who made use of intra-state portable ration cards (13).

From our interviews with local experts studying ration card policies, we see several potential reasons why intra-state portability helped drive down intra-state mobility during the lockdown, but inter-state portability did not do the same for inter-state mobility. First, formal policy may require lead time to be effective. The implementation of intra-state portability was initiated in 2015, with the state of Andhra Pradesh adopting it first, and by the end of 2017, intra-state portability was implemented in six states: Andhra Pradesh, Haryana, Jharkhand, Karnataka, Chhattisgarh (750 fair price shops), and Telangana. In contrast, inter-

state portability of ration cards was launched in August 2019 for two state-dyads: Andhra Pradesh-Telangana and Maharashtra-Gujarat, and the policy was extended to the single cluster of 12 states in January 2020 (11). In other words, the implementation of intra-state portability began four years prior to the implementation of inter-state portability and this difference in lead time might explain our results. Second, inter-state migrants, compared to intra-state migrants, are usually less socially and linguistically embedded within their host communities. Local ration shops may see out-of-state migrants as outsiders and impose restrictions, and it might be more difficult for inter-state migrants to receive information about the portability rules. Due to the lack of social embeddedness, inter-state migrants are also less likely to be aware of how to access food rations in their host states. Third and importantly, incentives are misaligned across state borders: the host state has few incentives to pay for migrants' rations because those migrants are not voters in that state; procedure-wise, it is also difficult for the host state to accurately identify the home state of each migrant. Our interviews with experts also highlighted an additional concern for states such as Tamil Nadu and West Bengal, which gave local residents ration in excess of the national quota for subsidized food. Here there were concerns in also giving migrants "excess ration" if indeed these states signed up for the inter-state ration card portability project.. Given these implementation problems related to mis-aligned incentives between states and information frictions, the World Bank recently issued a US$ 1 billion loan to facilitate the transfer of benefits for migrants and poor people in Indian cities, with an expressed objective of prioritizing implementation of the one-nation one ration card project (22). In addition to the anecdotal evidence, further research needs to be conducted to study the pain points of inter-state migrants in accessing subsidized food across state borders.

Coarsened exact matching:

In our analysis for intra-state portability and intra-state movement, identification could be confounded by inherent differences between portable and non-portable regions such as pre-existing migration trends and local development, which may have differential effects on migrant's movement after the lockdown in portable versus non-portable states. We use coarsened exact matching (CEM) to non-parametrically control for the confounding influence of pre-lockdown control variables, such that 1) movement dyads in portable regions (treated group) exhibited minimal differential movement trends compared to those in non-portable regions (control group) prior to the lockdown, and 2) the two groups are highly similar in terms of local development (23). To do that, we first selected a small number of control variables on which we want to guarantee balance: log(Baseline Movement), log(Nightlight in the starting subdistrict), log(Nightlight in the ending subdistrict), Percentage of Population that are Migrants in the starting district, Percentage of Population that are Migrants in the ending district, Percentage of Population that are Inter-State Migrants in the starting district, and Percentage of Population that are Inter-State Migrants in the ending district. Second, we coarsened each of those variables with strata that assign the same numerical value to all values within a stratum. Each stratum contains at least one treated and one control movement observation. Essentially, we match a treated observation if and only if a control observation is available in the same stratum. Wider strata (more coarsening) result in fewer strata, which result in more diverse observations within a stratum at the cost of higher imbalance (24).

Our CEM procedure has reduced the multivariate imbalance between the control and treated groups (the L1 measure) from 0.92 to 0.78. It has yielded 10,846 subdistrict-subdistrict movement dyads (7,998 in portable states and 2,848 in non-portable states). The matched sample is about one third of the original sample, which contains 29,043 movement dyads. Despite the smaller sample size, regression results show that intra-state portability is associated with 14% reduction in intra-state movement after the lockdown ($p=0.01$). The

effect of fully implemented intra-state portability on movement is about -20% (p=0.00). In summary, the CEM results offer strong support to our main findings.

Local Food Distribution and Mobility

We also study the relation between food distribution by local institutional and civil society stakeholders and human mobility. This is important to study given anecdotal evidence of frictions relative to implementing the portability policy (see SI Anecdotal Evidence section for more information). Notably, the portable ration card policy permits purchase of half the subsidized grains at one time in an effort to prevent one member of the household taking the entire ration for the month, leaving family members in a different location stranded without food (25). Additionally, in states such as Jharkhand, there is a large number of pending ration card applications, implying that many migrants from these states are excluded from the rationing process. As an example, many stranded migrants in Aurangabad, Maharashtra have been reported to lack ration cards or any official identification and face starvation (26). Considering the variation in policy implementation across locations, local food distribution efforts likely play an important role in providing food security to migrants in the immediate term.

To test the relationship between local food distribution and human mobility, we collected data from local and national newspapers and magazines on the activities of police, ration shops, and civil society actors distributing food. We searched for certain combinations of keywords in news articles for each state and for every day in our window of observation. Two examples of such activities include: accounts of how Uttar Pradesh has provided food to 35,843 beneficiaries of the *Antyodaya* scheme that seeks to provide food to the poorest of the ration card holders (27), and news that the District Magistrate of the *Purba Bardhaman* district in West Bengal directed that all citizens with pending ration card applications get

access to subsidized food (28).[4] We then counted the number of mentions of those keywords and aggregated the variables at the state-day level to form a variable measuring the level of activity by police, ration shops, and civil society actors distributing food in a given state (see SI for detail on variable construction). We find that the doubling of activities by police, ration shops, and food distributors are respectively associated with 0.0% (p=0.20), 1.0% (p=0.00), and 1.5% (p=0.00) decreases in intra-state mobility (SI Table S3). In other words, increased activities by ration shops and private food distributors in a given state are both significantly associated with lower intra-state mobility, but police activities are not associated with significant movement changes. We also apply CEM to test the effects of institutional activism on movement. Results remain robust.

Additionally, we apply the same test to inter-state mobility. Regressions show that the doubling of ration shop activities in a given state is associated with 1.6% decrease in inter-state mobility (p=0.02) (SI Table S7 Panel B). The effects of police and private food distributors are statistically insignificant. This result indicates that increased activity by local ration shops might have helped migrants avoid traveling. Overall, our results on both intra-state and inter-state movement indicate that local stakeholders like ration shops and private food distributors play a key role in helping migrants stay in their host locations. Regarding intra-state movement, local activism is complementary to the mobility-reducing effect of intra-state ration card portability. Regarding inter-state movement, local activism is essential for inter-state migrants during the lockdown, because inter-state ration card portability is not correlated to inter-state mobility.

[4] Examples of news articles with the ration shop keywords contain sentences such as: "*… all commercial and private establishments would be shut, but with exceptions: shops, including ration shops dealing with food, groceries, fruits and vegetables, dairy and milk booths, meat and fish, animal fodder*." (Punjab, April 1, 2020.) Examples of news articles with keywords related to private food distribution by civil society actors contain sentences such as: "*Shaikh belongs to Falah-e-Aam, a charitable trust. His group of 20-odd members started doling out biscuits for breakfast and vegetarian food packets sourced through a local caterer for lunch and dinner to labourers this weekend."* (Uttar Pradesh, March 26, 2020.)

We also employ supplementary natural language processing (NLP) analysis to code the text of the news articles, in order to alleviate concerns that other observable state actors (such as local politicians) are responsible for ration shops or civil society actors distributing food. Our NLP analysis indicates that the effects of rationing on mobility reduction is not plausibly confounded by activities of other observable state actors (SI Figure S4).

Discussion

This study highlights the significance of food security in curbing human mobility during the COVID-19 outbreak. Specifically, our findings indicate that a policy to guarantee food security for intra-state migrants, in the form of intra-state portability of ration cards, is associated with 12% reduction in human mobility within a state, and the effect is stronger among states that had fully implemented the policy than among states with partial implementation. However, food security policy at the national level, in the form of inter-state portability of ration cards, is not associated with any significant inter-state movement reduction. We also provide evidence that local activities by ration shops and civil society actors distributing food are related to curbing both intra- and inter-state mobility.

Our study contains specific policy implications and generalizable insights for the social science research on migration. First, India should take immediate steps to roll out intra-state portable ration cards to all states. However, given the time needed to effectively implement this policy (as evidenced by the results related to states with full and partial implementation), immediate-term food distribution needs to be arranged by local governments, ration shops, police, and civil society actors. Second, inter-state portability of ration cards has so far been ineffective in curbing inter-state mobility during the crisis—our results are consistent with the data provided by the Indian Food Ministry on the uptake of intra-state and inter-state portability of ration cards (summarized earlier in the paper). Inter-state policy implementation frictions remain, in terms of lead time needed for technology

adoption, building awareness, and alleviating potential local discrimination. In the meantime, inter-state migrants (about 12% of India's internal migrants) remain especially vulnerable to food security concerns during the COVID-19 lockdown, and the importance of local ration shops and civil society actors in feeding these migrants during the crisis cannot be overstated.

More broadly, our results are generalizable to countries around the world where migrants face regulatory, occupational, and economic frictions in moving across borders (29–31). During crises that affect livelihoods (e.g., pandemics, natural disasters, political conflicts, industry shocks), migrants are often forced to travel to seek food (8–10, 32). Our results suggest that governments worldwide should work to ensure food security for migrants during times of crisis. Moreover, policy implementation frictions and insufficient lead time for effective policy roll-out might render nationwide policies ineffective in response to an immediate crisis, amplifying the need for local governments and civil society stakeholders to provide short-term relief to migrants. These insights are important during all types of crises, but they are especially critical during the current COVID-19 crisis. Migrants who travel despite lockdown orders not only endanger their own health, but also risk increasing the spread of the virus to other parts of the world.

Finally, our study also contributes to the research on food security and migration. Social science has a long tradition of studying costs and risks borne by migrants, and even the early theoretical models of human migration incorporated expenditure related to food (33). While the decision to migrate is related to maximizing expected income from the move (34), other literature points to how migrants attempt to mitigate risks related to market failures (35, 36). In particular, research has highlighted how food security policies (such as those related to crop insurance) affect the incentives of migrants facing natural calamities (37). Our work opens the door to several avenues of future research. Notably, prior research on the role of civil society actors in providing food security to within-country migrants has been relatively

sparse. Our study suggests that civil society actors might play an important role in complementing public policy and providing food security to migrants. As the COVID-19 crisis subsides and the policies of interest (i.e. intra-state and inter-state portability of ration cards) are implemented across the country, it will also be interesting to study whether there is a structural change in migration flows between states and/or between subdistricts of the same state. India has had a historically low cross-district migration rate (2.8%), even compared to other developing countries such as China (10%) and Brazil (9%), and the non-portability of ration cards has been identified as a key friction to these migration rates (4). It will be particularly interesting to study whether and how the implementation of the 'One nation one ration card' policy over the next few years changes domestic migration flows over time.

This study is subject to several boundary conditions. First, our Facebook movement data include users who have downloaded the Facebook app on their smartphones. Although the social media platform has a wide user base in India (over 300 million users), our sample may represent a selected, perhaps wealthier, portion of the population. However, this constraint also plausibly biases against finding significant relationships between intra-state portability of ration cards and intra-state movement because migrants with smartphones might be less prone to food security issues. Second, our proxies for institutional activities are generated using news data from English-language newspapers and periodicals. Despite the widespread nature of English readership in India, the measurement of activities might be confounded with regional and linguistic variation in publication of news.

In conclusion, COVID-19 represents not only a health crisis, but a crisis of food insecurity and starvation for migrants. Public policies that provide food security have the potential to help migrants restrict movement, but policy implementation needs lead time and may be less effective when implemented across borders. Food distribution activities by local

governments, stakeholders, and civil society actors are needed to tide migrants over through the crisis.

Materials and Methods

Please refer to SI "Data and Methods" section for details on data collection, variable construction, and model specifications. Figures 1 and 2 are produced using *sf* and *ggplot2* packages.

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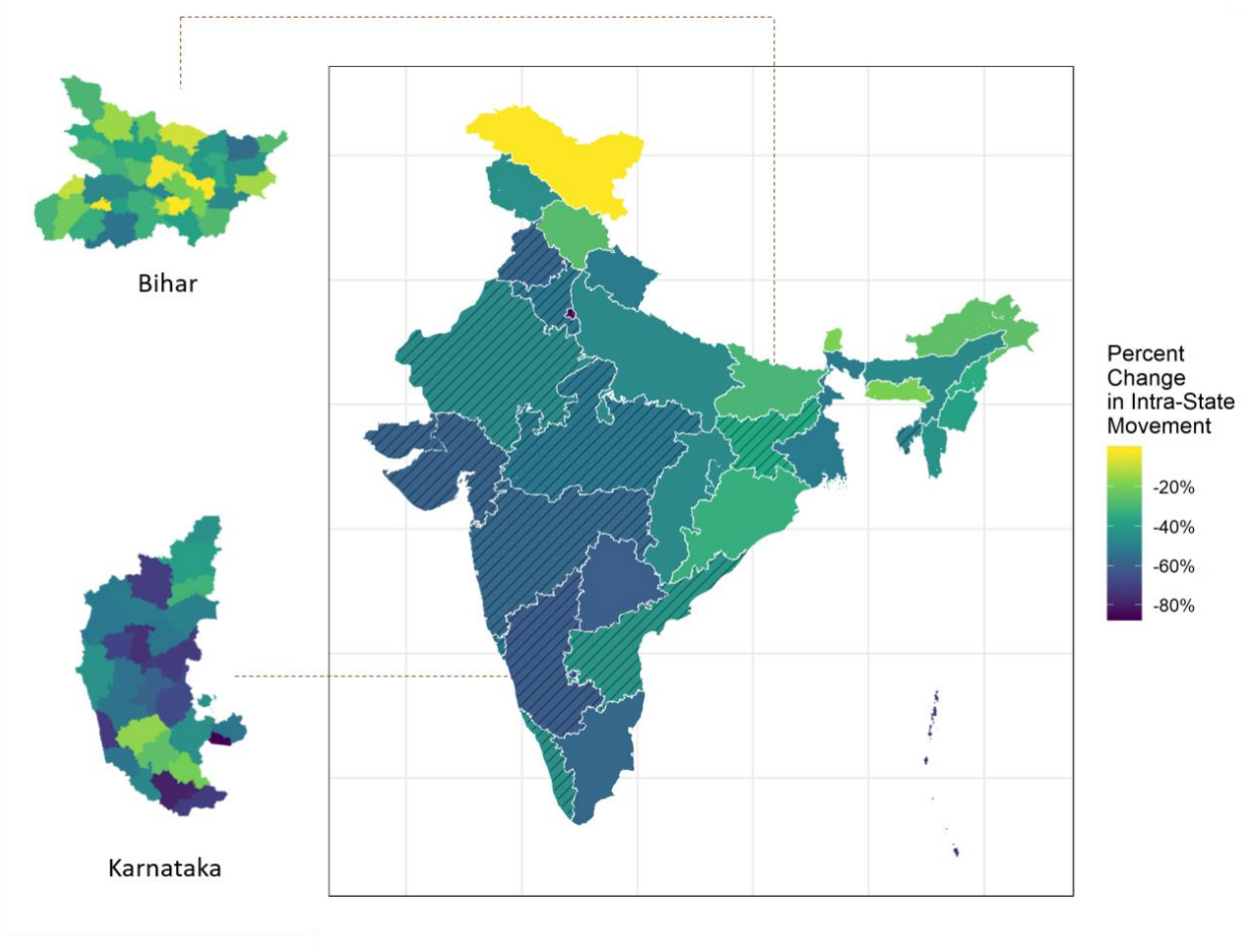

Figure 1. Map of Percentage Change in Intra-State Mobility. This map shows the percentage changes in average *intra-state* mobility from pre- to post-lockdown in different states. The value assigned to a given state is calculated by averaging the intra-state mobility originating from all subdistricts in that state. States with full intra-state ration card portability are marked by stripes. The submaps represent district-level breakdowns of the intra-state mobility in Bihar (partial implementation of intra-state portability) and Karnataka (full implementation of intra-state portability), with a larger number of districts displaying substantial movement reduction (dark blue) in Karnataka than in Bihar. These descriptive trends are in accordance to the econometric evidence presented in Table 1.

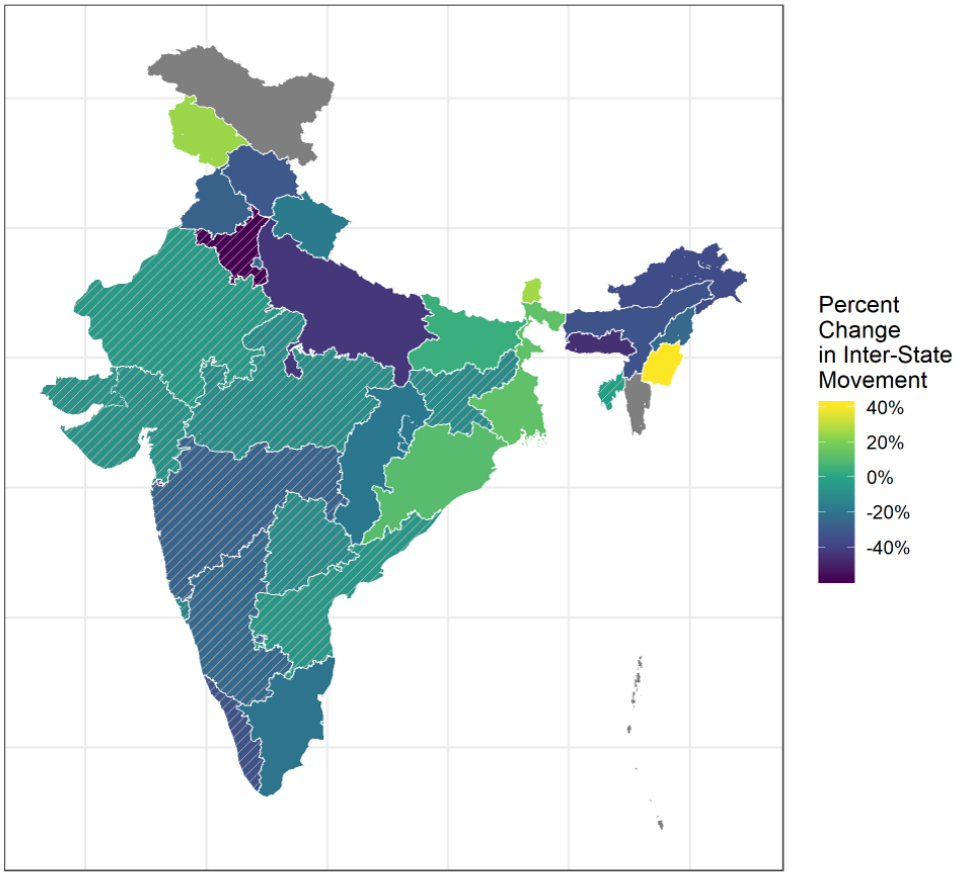

Figure 2. Map of Percentage Change in Inter-State Mobility. This map shows the percentage changes in average *inter-state* mobility from pre- to post-lockdown in different states. The value assigned to a given state is calculated by averaging the inter-state mobility originating from all subdistricts in that state. States with inter-state ration card portability are marked by stripes. Relative to the intra-state mobility map (Figure 1), this inter-state mobility map shows less descriptive evidence in support of the policy having a mobility reducing effect and some portable states (e.g., Andhra Pradesh, Gujarat, Telangana) showed only minor reductions or no change in inter-state mobility. These results can be understood in light of the extremely low participation of inter-state migrants in the program: according to data from the Food Ministry of India, only 200 inter-state migrants retrieved food at their host locations in April 2020 using inter-state portable ration cards, compared to 650,000 intra-state migrants who made use of intra-state portable ration cards.

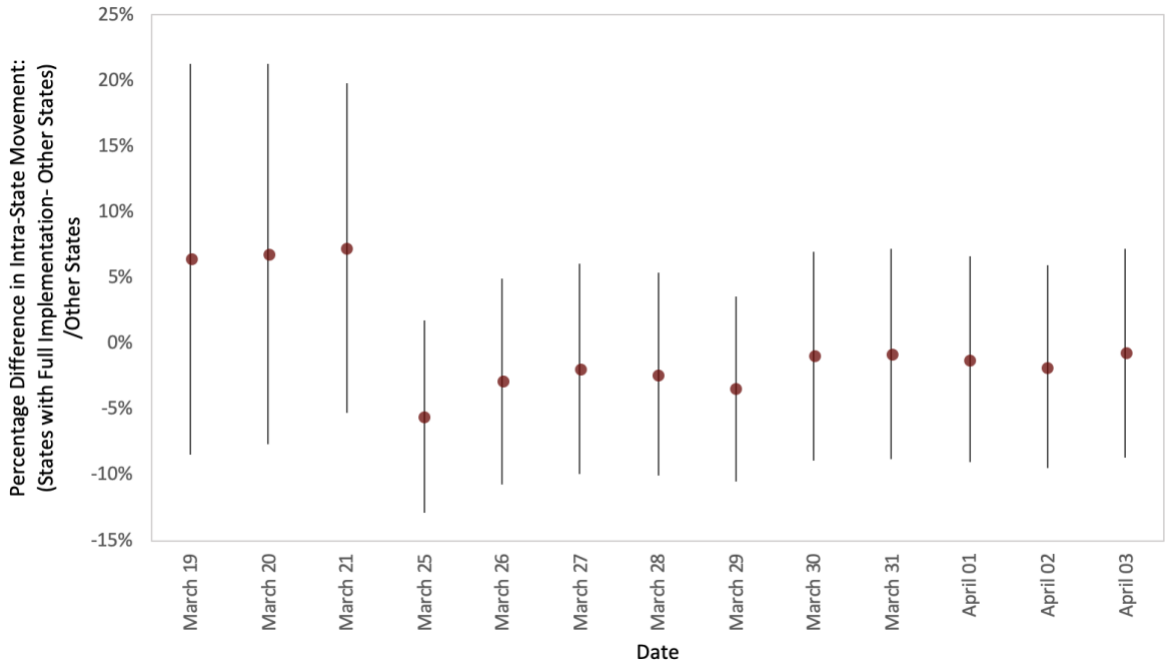

Figure 3. Movement Difference Between Fully Intra-Portable States and Other States Over Time. The movement difference for each day is generated by calculating the percentage difference between the average number of intra-state movers in states that had fully implemented intra-state portability and that in other states on that day. Negative percentages indicate less movement in states with full implementation of portability than other states. The downward temporal trend shows that fully portable states experienced greater movement reductions than other states over time. Error bars indicate 95% confidence intervals. The pre-period consists of March 19 to 21. The post-period consists of March 25 to April 3 (March 22-24 are excluded due to a nationwide curfew implemented before the lockdown).

Table 1. Intra-State Portability of Ration Cards and Intra-State Mobility Change Following the Lockdown.

Dependent Variable	*log(Intra-State Mobility Between Subdistricts)*		
	(1)	(2)	(3)
Post × *Intra-State Portability*		-0.129***	
		(0.032)	
Post ×*Full Intra-State Portability*			-0.157***
			(0.035)
Post × *Partial Intra-State Portability*			-0.086**
			(0.036)
Post	-0.223***	-0.140	-0.158
	(0.008)	(0.121)	(0.121)
Post × *log(District Population)*		0.152***	0.132**
		(0.056)	(0.058)
Post × *log(State Area)*		-0.023	-0.007
		(0.020)	(0.022)
Post × *Nightlight*		0.002	0.002
		(0.008)	(0.008)
Post × *log(Migrant)*		-0.025	0.000
		(0.054)	(0.056)
Post × *log(Inter-State Migrant)*		-0.013	-0.013
		(0.016)	(0.016)
Post × *log(Number of Ration Card)*		-0.011	-0.023
		(0.016)	(0.017)
Subdistrict FE	Yes	Yes	Yes
Adjusted R_2	0.193	0.183	0.183
Observations	219,671	116,690	116,690

Note: These regressions are generated using ordinary least squares with logged dependent variables. Standard errors in parentheses are clustered at the subdistrict-subdistrict dyad level. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

Supplementary Information for

Food Security and Human Mobility During the Covid-19 Lockdown

This document includes:

Data and Methods

Tables S1 to S10

Figures S1 to S3

Anecdotal Evidence

Supplementary References

Data and Methods

Mobility Data

Our mobility data is from the Facebook Data for Good project (21). Facebook's Data for Good team developed and provides access to the GeoInsights portal to provide mobility and population level data in response to crises. This interface allows researchers and response workers to request aggregated and anonymized datasets generated by an open cohort of individuals who are Facebook users, have smart phones, and are providing information through the Facebook app by having location services enabled. Data are requested for a geospatial region and defined by a spatial bounding box. We are provided with population data that indicate how many users are in a given location and the mobility data that contain the number of users moving from point to point. In this study, we primarily rely on the mobility data, but use the population data for additional analysis. When the data aggregation pipeline is initiated, all users who are in the cohort described above and inside the bounding box contribute information to the datasets. For each user, location information is collected, and user location is categorized to Bing Tiles. The resolution of the Bing Tiles used varies by type of dataset (see Figure S1 for a comparison of the centroids of the tile data) with population data being offered at a higher resolution than mobility data due to computational restrictions. Data are then aggregated into 8-hour bins. Population is determined by the modal location for each user during this 8-hour bin.

The mobility data are at the location-dyad level. Mobility for a given 8-hour bin is defined as a vector of transitions with the destination being the modal location in the current 8-hour bin and the origin being the modal local for the preceding 8-hour bin. For each population tile and mobility vector, Facebook provides a baseline which is calculated as the average number of users who had been in a given location (population data) and made a given transition (mobility data) during the baseline period, conditional on day of week and

time of day. The baseline period is defined as the 45-day period preceding the initiation of the pipeline. In our data this is the 45 days preceding March 19th, 2020. For instance, the baseline mobility for mobility from tile A to tile B during the 1:30 pm-9:30 pm time slot on Wednesday, March 26th consists of the average number of users moving from tile A to tile B on the six Wednesdays prior to March 19th during the 1:30 pm-9:30 pm time slot.

We download these data as a comma separated volume (CSV) for each 8-hour bin starting March 19th. For population data we are provided with the geospatial centroid of each Bing Tile, the average population in that Bing Tile during the baseline period and the actual count of users who were in that Bing Tile during a specific 8-hour period. For mobility data, we are provided with the geospatial centroid of the origin and destination tiles, the great-circle distance between these two points, the average pairwise transitions of users from one tile to another during the baseline period and the specific number of users who made that transition during a given 8-hour period. For both population and mobility data, tiles are dropped if they contain fewer than 10 users. For both datasets, we remap the centroids of the tiles to our spatial unit of interest – official subdistrict boundaries in India. A subdistrict is two administrative levels under that of the state. Thus, our mobility data is at the subdistrict-subdistrict dyad-level, containing information on the number of users moving between subdistrict dyads (can be within subdistrict mobility) on a given day.

Local Institutional Data

We also collected data on the activities of several local institutional actors – police, ration shops, and private food distributors. On Factiva, we used different combinations of keywords to search for news articles in local newspapers and periodicals. The keyword for police activities is "police." The keyword for ration shop activities is "ration shop." The keyword for food distribution is "distribute food." For each Indian state, all searches were conducted with the constraint that the articles must include keywords related to the virus

outbreak (either "Covid" or "coronavirus") and the name of the particular state. Essentially, we expect our searches to yield targeted news articles that cover the activities of police, ration shops, and private food distributors that are related to or in the context of COVID-19. We only searched for articles in the English language. This is a limitation in the sense that news is often covered in local languages (there are 22 scheduled languages in India, written in 13 different scripts and with over 720 dialects). However, given the nature of English as a commonly used language in India, where there are close to 14,000 English newspapers and periodicals, our capture of the articles is meant to deliver a good estimate of the relative extent of local institutional activities across different states. The list of newspapers and periodicals that contributed to our news data is displayed in Table S9.

Time-Invariant, Regional Data

We collected data on a host of time-invariant, regional variables on police force, ration shops, and migration. Data on regional population is from the 2011 national census in India. Data on the number of ration card holders is from the 2019-20 annual report of the "One Nation One Card" Project. Data on nightlight (2018 data) is from the National Centers for Environmental Information (NCEI). Finally, data on regional historic migration (e.g., number of migrants in each state, percentage of inter-state migrants) is provided to us by Chinmay Tumbe, who compiled the data based on results from the 2001 national census and the 2008 National Sample Survey.

Methodology

Methods Overview

In this study, we quantify the effects of ration card portability (intra-state and inter-state) and local activism on the number of people moving intra-state and inter-state before and after India's Covid-19 lockdown. Our pre-period consists of March 19-21, 2020. Our post-period consists of March 25-April 3, 2020. We removed March 22-24 from our analysis to avoid

confounding effects of a previously announced voluntary curfew and its immediate aftermath between March 22-24, which introduces a different type of treatment from the mandatory lockdown and may confound interpretation. Mobility data are acquired from Facebook, in collaboration with the platform's 'Data for Good' team (see previous section). Roughly 25% of India's population are on Facebook (over 300 million users), and vast majority of India's Facebook users access Facebook via smartphones. Thus, results from this study are more applicable to migrants with smartphones.

The treatment variables are operationalized as the products between two pairs of binary variables: *Intra-Portable X Post-Lockdown* and *Inter-Portable X Post-Lockdown*. The variable equals 1 for mobility that started from intra-/inter-portable states in the post-period, and 0 otherwise. For the analysis involving local institutional activism, we constructed three variables, *Police Activities*, *Ration Shop Activities*, and *Private Food Distribution Activities*, using daily data from English-language newspapers and periodicals in India. These variables are calculated as the number of words associated with each local institutional actor mentioned in the newspapers and periodicals in a state on a given day. The assumption is that increased news mentions associated with an institutional actor indicates an increased level of activities by that institutional actor in its state on that day (Table S2 provides summary statistics and pairwise correlations for all variables).

Final Sample

Our final sample covers two periods: March 19th to March 21st form our pre-period, and March 25th to April 3rd form our post-period. We exclude March 22nd to March 24th to avoid the confounding effects of certain events. First, the "Janata Curfew" happened on March 22nd, and it asked people to voluntarily stay home and curb their mobility. Shortly after the curfew, people experienced widespread uncertainty about the impending lockdown, prompting many to panic and to travel (38). Thus, the exclusion of those days of high

uncertainty provides a cleaner setup where mobility in the pre-period is more representative of ordinary mobility, and the post-period is less impacted by confusion and panic.

The final sample consists of 219,671 observations at the subdistrict-subdistrict-date level (Table S2, Panel A), with 116,690 observations in the main regressions (there are missing values due to the time-invariant data such as historic migration and nightlight levels). The average number of users making inter-subdistrict mobility within a state (*Mobility*) on a given day is about 148, while average Baseline Mobility (number of people who would ordinarily make the same mobility prior to the lockdown) is about 359. This indicates that there was considerable mobility decrease during our sample period compared to the preceding days.

Model Specification

We estimate the differential effects of lockdown on inter-state mobility in states where ration cards are portable (*Portable* = 1) and in states where ration cards are not portable (*Portable* = 0). Here, by *Portable,* we are referring to both intra-state and inter-state portability - the functional forms of the two sets of regressions are the same. Similarly, by *Mobility,* we are referring to both intra-state and inter-state mobility. To do that, we employ ordinary least squares (OLS) to regress the number of users making mobility on a given day on the treatment variable, which is an interaction term between the portable state dummy and the post-lockdown dummy. Below is our model specification:

$$Mobility_{i,j,t} = \beta_1 \, Post_t \times Portable_i + \beta_2 \, Post_t + Controls + \alpha_i + \epsilon_{i,j,t} \quad (1),$$

where $Mobility_{i,j,t}$ is the number of users who moved from subdistrict *i* to subdistrict *j* (can be the same subdistrict) on day *t*. $Post_t$ equals 1 for all observations post-lockdown, and 0 for observations pre-lockdown. We also include several control variables at the mobility-level and the regional level. We include the interaction terms of *Post* and *District population* (in millions of people, logged; the district is one level above the subdistrict and one level below the state), *State Area* (in thousands of square kilometres, logged), *Amount of Nightlight*

in a subdistrict (2018 composite light index given by the National Centers for Environmental Information), *Number of Migrants* in a district (logged), *Number of Inter-State Migrants* in a district (logged), and *Number of Ration Cards* in a state (in millions of ration cards, logged). Finally, α_i indicates subdistrict fixed effects to absorb unobserved heterogeneity specific to the subdistrict from which the mobility is made, which may influence β_1. In all models, the standard errors are clustered at the subdistrict-level. Our main results (reported in manuscript) are robust to intra-state inter-district level analysis (Table S5) and several alternate specifications (Table S6).

Our second set of analysis concerns the effects of local institutional activism on mobility after the lockdown. The model specification is as follows:

$$Mobility_{i,j,t} = \beta_1\, Post_t \times Local\ Activism_{i,t} + \beta_2\, Post_t + Controls + \alpha_i + \epsilon_{i,j,t} \quad (2),$$

Where the $Local\ Activism_{i,t}$ variables consist of *Police Activism*, *Ration Shop Activism*, and *Food Distribution Activism* (by civil society actors) in state *i* on date *t.* They are measured by the number of times each respective set of keywords are mentioned in relation of COVID-19 and the particular state. For more information on the keywords used to generate these news articles, please refer to the prior section on "Local Institutional Data." In the current setup, all time-invariant independent variables are multiplied by *Post* to form time-variant interaction terms. We did not include their main effects because they would drop out in the presence of location fixed effects. We re-ran the models without location fixed effects while including the time-invariant main effects of the institutional activism variables. Results remain similar.

Machine Learning Analysis

It is important to address the possibility that the observed relationship between rationing activities and mobility reduction is driven by other unobserved factors. To test this, we ran

Word2vec machine learning models on the text of the press articles that mention 'Covid-19 and ration shops' and articles that mention 'Covid-19 and food distribution'.

Figure S2 shows the two dimensional projections of the top 20 words in the "food distribution" and "ration shop" articles whose vectors are most similar to the word 'distribute' (root form for distribute, distribution etc.) and vectors most similar to the word "ration". Here the similarity is measured by the dot product of the two vectors. For both these graphics, we have the top 20 similar words and for each of these 20 words (and the original word), we have a 30-dimensional word2vec vector (which is fixed) and a 2-dimensional TSNE vector. Since TSNE is a non-deterministic algorithm, the actual coordinates differ on every run but the separation between two words is the same.

The analysis reveals that food distribution was done by both civil society actors ('NGOs', 'volunteers') as well as by the police ('Sub Divisional Police Officer', 'Station House Officer'). However, there is no mention of any state or civil society actors in articles that mention ration shops, indicating that the effects of rationing on reduction of mobility is not plausibly confounded by other observable state actors. Apart from that, we also have the similarity (dot product) of the top 20 words with the original word which can be used to sort the words by the most similar. This analysis reveals that there are no observable mentions of other state actors in articles mentioning ration shops indicating that the effects of rationing on reduction of mobility is not plausibly confounded by activities of other observable state actors.

Finally, we used another machine learning technique to test the robustness of *Portable* effect on reducing mobility (Figure S3). We used a Random Forest Regressor to test the differences in mean absolute error (MAE) between models that include the 'full intra-state portability' variable and models that exclude it. Our results indicate that the MAE decreased after including *Full intra-state portability* in both train and test datasets, suggesting that the

predictor *Full* Intra-state *portability* is a valid predictor for inter-state mobility. The note underneath Figure S3 provides more detail on the technique.

Tables & Figures

Table S1. Examples of Food Security Issues in India and Other Countries

Country	Example	Source
India	Migrants have mostly lost their income sources. In many Indian cities, they are dependent on government and charity handouts for food. Some are reduced to begging for food. In some feeding centres, people are seeing 2-kilometer-long queues and stampedes when food runs out.	BBC[5]
India	Migrants often do not benefit from the free ration schemes set up by local governments. Many migrants do not belong to the beneficiary lists on those schemes. The online system for e-coupons is often delayed due to technical issues and high volume.	Outlook India[6]
India	Delhi's food ration scheme leaves out millions of poor people and migrants. The schemes are usually based on the 2011 census, so unregistered people and migrants whose ration cards do not work there cannot obtain rations. Even though many have enrolled in the Aadhaar (India's national ID database), they still cannot obtain a ration card to access subsidized grains.	Al Jazeera[7]
Nigeria, Kenya & South Africa	In Nigeria, transportation and trade have come to a halt, so there is no company or organization to move the food around. Sub-Saharan Africa is the world's largest rice-importing region, and it could be heading into a food crisis. In Kenya and East Africa, Covid-19 coupled with the locusts plague have dried up governments' food reserves. Supply chain has also been disrupted, so supply cannot get to the demand. Stampedes have occurred over food. In South Africa, aerial footage shows that thousands have queued up for charity food. The line was 4 kilometres long, near shantytowns on the outskirts of Johannesburg. Most of the food seekers are foreign migrants from nearby countries like Zimbabwe. They do not qualify for	WEF[8] New York Post[9]

5 https://www.bbc.com/news/world-asia-india-52360757
6 https://www.outlookindia.com/website/story/india-news-migrants-fight-hunger-as-glitches-mar-kejriwals-free-ration-scheme/350935
7 https://www.aljazeera.com/news/2020/04/india-hunger-uncertainty-delhi-coronavirus-lockdown-200418095253032.html
8 https://www.weforum.org/agenda/2020/04/africa-coronavirus-covid19-imports-exports-food-supply-chains
9 https://nypost.com/2020/04/30/aerial-footage-shows-miles-long-queue-for-food-aid-in-south-africa/

	government food rations, which are not enough to take care of South Africa's poor in the first place.	
United States	In Omaha, a food bank that typically serves 100 people saw 900 people show up on a single day. In Washington State and Louisiana, the National Guard has been called into help pack food boxes and ensure smooth distribution. Feeding America, the biggest network of food banks in the U.S., projects a $1.4 billion shortfall in the next six months. Food donations fell by more than half, and food prices for food banks increased nearly tenfold. In Ohio, where 1 million people lost their jobs, 30 thousand Ohioans applied for food stamp benefits in one week in April, almost tripling the applications during the same period last year.	The New York Times[10] Dayton Daily News[11]
Belgium & Italy	In Belgium, charities and NGOs have to decrease service or shut down because volunteers are no longer working. The situation might lead to an increase in the number of homeless people when people are supposed to remain indoors. In southern Italy, charity groups reveal that "people are calling us not because people are sick from the virus, but because people are hungry." Hunger is a particularly severe issue among the migrant population, mostly from West and North Africa.	The Nation[12]
Malaysia & Singapore	Malaysia has about 5.5 million foreign migrant worker, more than half of whom are undocumented. Many have not gotten paid since February, and even the cheapest food source (rice and lentil) have become a luxury. Malaysian officials have argued that the welfare of foreign migrants is the responsibility of their respective embassies. In Singapore, migrant workers make up most of the infected cases. Over 20,000 migrants are quarantined in dormitories. The government requires that these migrants' Singaporean employers provide sufficient food, but that is often difficult since many companies are going through financial crunch. Migrants have to rely on help from the government, NGOs and churches.	SCMP[13] Reuters[14]

10 https://www.nytimes.com/2020/04/08/business/economy/coronavirus-food-banks.html
11 https://www.daytondailynews.com/news/local/coronavirus-food-stamp-demand-soars-ohio/X82GGAvZ0Kp4mVxbU42GzK/
12 https://www.thenation.com/article/world/eu-migration-covid/
13 https://www.scmp.com/week-asia/health-environment/article/3081310/coronavirus-malaysias-migrant-workers-lack-food-bigger
14 https://www.reuters.com/article/us-health-coronavirus-singapore-migrants/pastor-helps-keep-singapores-migrant-workers-fed-during-covid-19-lockdown-idUSKCN22505D

Table S2. Summary Statistics and Correlation Table

Panel A. Summary Statistics

Variable	N	Mean	SD	Min	Median	Max
Intra-State Mobility Between Subdistricts	219,671	148.40	784.4	10	62	53,500
Post	219,671	0.64	0.479	0	1	1
Intra-State Portability	116,690	0.84	0.37	0	1	1
Full Intra-State Portability	116,690	0.66	0.48	0	1	1
Partial Intra-State Portability	116,690	0.18	0.39	0	0	1
Police Activism	116,690	95.05	83.95	0	78	389
Ration Shop Activism	116,690	0.61	1.09	0	0	5
Food Distribution Activism	116,690	1.58	3.11	0	0	24
District Population (million)	116,690	2.85	1.86	0.05	2.45	11.06
State Area (thousand km2)	116,690	180.70	104.90	3.70	163.00	342.20
Nightlight (subdistrict average radiance composite)	116,690	2.16	2.97	0.37	1.47	33.53
Migrants (million)	116,690	0.95	0.86	0.01	0.73	6.30
Inter-State Migrants (million)	116,690	0.13	0.27	0.00	0.05	2.62
Number of Ration Cards (million)	116,690	11.85	10.71	0.14	11.11	56.35

Notes: The variables 'migrants' and 'inter-state migrants' are at the district level, while the variable 'number of ration cards' is available and coded at the state level. Historic Migrant data is provided to us by Chinmay Tumbe, who compiled the data based on results from the 2001 national census and the 2008 National Sample Survey. Nightlight data is accessed via the National Centers for Environmental Information. State-level ration card data is from the India Food Ministry's annual reports.

Table S2. Summary Statistics and Correlation Table (N=116,690)

Panel B. Correlation Table

		1	2	3	4	5	6	7	8	9	10	11	12	13	14
1	*Intra-State Mobility Between Subdistricts*	1													
2	*Post*	-0.08	1												
3	*Intra-State Portability*	-0.01	0.01	1											
4	*Full Intra-State Portability*	0.02	0.01	0.61	1										
5	*Partial Intra-State Portability*	-0.04	0.00	0.21	-0.65	1									
6	*Police Activism*	0.01	0.39	0.17	0.30	-0.20	1								
7	*Ration Shop Activism*	-0.04	0.42	0.09	0.01	0.07	0.10	1							
8	*Food Distribution Activism*	-0.01	0.28	-0.02	0.06	-0.08	0.13	-0.03	1						
9	*District Population*	0.13	-0.06	0.04	0.05	-0.02	0.18	0.02	0.09	1					
10	*State Area*	0.01	0.01	0.39	0.54	-0.29	0.17	0.02	0.10	0.16	1				
11	*Nightlight*	0.17	-0.06	0.01	0.01	0.00	0.04	-0.02	0.01	0.50	-0.02	1			
12	*Migrants*	0.14	-0.06	0.09	0.16	-0.11	0.25	-0.01	0.10	0.92	0.22	0.49	1		
13	*Inter-State Migrants*	0.15	-0.05	0.13	0.18	-0.10	0.15	-0.02	0.04	0.70	0.14	0.66	0.82	1	
14	*Number of Ration Cards*	-0.01	-0.01	-0.33	-0.29	0.05	-0.03	0.05	0.01	0.31	0.04	0.00	0.19	0.00	1

Table S3. Local Institutional Activism and Intra-State Mobility Change

Dependent Variable	*log(Intra-State Mobility Between Subdistricts)*			
	(1)	(2)	(3)	(4)
Post × log(Police Activism)	-0.002			-0.003
	(0.003)			(0.003)
Post × log(Ration Shop Activism)		-0.008***		-0.010***
		(0.003)		(0.003)
Post × log(Food Distribution Activism)			-0.012***	-0.015***
			(0.003)	(0.004)
Post	-0.162	-0.169	-0.166	-0.151
	(0.122)	(0.122)	(0.122)	(0.122)
Post × log(District population)	0.156***	0.156***	0.158***	0.158***
	(0.056)	(0.056)	(0.056)	(0.056)
Post × log(State Area)	-0.049***	-0.049***	-0.050***	-0.049***
	(0.018)	(0.018)	(0.018)	(0.018)
Post × Nightlight	0.004	0.003	0.003	0.003
	(0.008)	(0.008)	(0.008)	(0.008)
Post × log(Migrants)	-0.026	-0.025	-0.029	-0.024
	(0.054)	(0.054)	(0.054)	(0.054)
Post × log(Inter-State Migrants)	-0.023	-0.024	-0.023	-0.023
	(0.016)	(0.016)	(0.016)	(0.016)
Post × log(Number of Ration Cards)	-0.003	-0.003	-0.001	-0.001
	(0.017)	(0.017)	(0.017)	(0.017)
Start Subdistrict FE	Yes	Yes	Yes	Yes
Adjusted R^2	0.182	0.182	0.182	0.182
Observations	116,690	116,690	116,690	116,690

Note: Standard errors in parentheses are clustered at the subdistrict-subdistrict pair level. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$. The 'Food Distribution Activism' variable measures the amount of food-distribution activities by civil society actors such as charities and private donors.

Table S4 Intra-State Mobility Analysis of the CEM Sample

Dependent Variable	*log(Intra-State Mobility Between Subdistricts)*					
	(1)	(2)	(3)	(4)	(5)	(6)
Post × *Intra-State Portability*	-0.141***					
	(0.051)					
Post ×*Full Intra-State Portability*		-0.219***				
		(0.061)				
Post × *Partial Intra-State Portability*		-0.085*				
		(0.051)				
Post × *log(Police Activism)*			-0.003			-0.005
			(0.003)			(0.003)
Post × *log(Ration Shop Activism)*				-0.007*		-0.010***
				(0.004)		(0.004)
Post × *log(Food Distribution Activism)*					-0.025***	-0.029***
					(0.005)	(0.006)
Post	-1.008***	-1.065***	-0.719***	-0.725***	-0.726***	-0.725***
	(0.287)	(0.289)	(0.254)	(0.254)	(0.254)	(0.253)
Post × *log(District population)*	0.190	0.133	0.116	0.116	0.120	0.130
	(0.130)	(0.131)	(0.125)	(0.125)	(0.125)	(0.125)
Post × *log(State Area)*	0.013	0.055	-0.052*	-0.052*	-0.052*	-0.049*
	(0.038)	(0.044)	(0.027)	(0.027)	(0.027)	(0.027)
Post × *Nightlight*	0.033	0.008	0.031	0.030	0.031	0.032
	(0.039)	(0.040)	(0.039)	(0.039)	(0.039)	(0.039)
Post × *log(Migrants)*	-0.128	-0.046	-0.070	-0.070	-0.077	-0.080
	(0.127)	(0.128)	(0.123)	(0.123)	(0.124)	(0.123)
Post × *log(Inter-State Migrants)*	-0.076**	-0.083***	-0.069**	-0.068**	-0.067**	-0.070**
	(0.031)	(0.031)	(0.031)	(0.031)	(0.031)	(0.031)
Post × *log(Number of Ration Cards)*	0.038	0.024	0.062***	0.062***	0.064***	0.063***
	(0.025)	(0.025)	(0.024)	(0.024)	(0.024)	(0.024)
Start Subdistrict FE	Yes	Yes	Yes	Yes	Yes	Yes
Adjusted R_2	0.343	0.343	0.342	0.342	0.343	0.343
Observations	31,602	31,602	31,602	31,602	31,602	31,602

Note: We use CEM to match intra-state portable and non-portable subdistrict dyads based on their average pre-period characteristics. Specifically, the treatment variable is Intra-State Portability, and the variables along which the sample is matched are: log(baseline movement), log(nightlight in the starting subdistrict), log(nightlight in the ending subdistrict), percentage of migrants in the starting district, percentage of migrants in the ending district, percentage of inter-state migrants in the starting district, percentage of district-level inter-state migrants in the ending district. The original sample includes 23,015 and 6,028 portable and non-portable subdistrict dyads, respectively. The matching sample includes 7,998 and 2,848 portable and non-portable subdistrict dyads, respectively. The multivariate imbalance (L1) dropped from 0.918 to 0.777 after CEM. Standard errors in parentheses are clustered at the subdistrict-subdistrict dyad level. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

Table S5. Robustness Checks with Intra-State and Inter-District Mobility

Dependent Variable	*log(Intra-State Mobility Between Subdistricts)*		
	(1)	(2)	(3)
Post × *Intra-State Portability*		-0.190***	
		(0.047)	
Post × *Full Intra-State Portability*			-0.220***
			(0.052)
Post × *Partial Intra-State Portability*			-0.143***
			(0.056)
Post	-0.130***	-0.046	-0.053
	(0.013)	(0.165)	(0.164)
Post × *log(District population)*		0.075	0.047
		(0.088)	(0.092)
Post × *log(State Area)*		-0.027	-0.010
		(0.029)	(0.032)
Post × *Nightlight*		-0.008	-0.008
		(0.008)	(0.008)
Post × *log(Migrants)*		-0.030	0.001
		(0.084)	(0.087)
Post × *log(Inter-State Migrants)*		-0.007	-0.006
		(0.025)	(0.025)
Post × *log(Number of Ration Cards)*		0.076***	0.061**
		(0.027)	(0.028)
Start District FE	Yes	Yes	Yes
Adjusted R_2	0.214	0.190	0.190
Observations	101,086	51,445	51,445

Note: Standard errors in parentheses are clustered at the district-district dyad level. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

Table S6. Robustness Checks with Subdistrict and Date Fixed Effects

Dependent Variable	*log(Intra-State Mobility Between Subdistricts)*					
	(1)	(2)	(3)	(4)	(5)	(6)
Post × Intra-State Portability	-0.129***					
	(0.032)					
Post ×Full Intra-State Portability		-0.157***				
		(0.035)				
Post × Partial Intra-State Portability		-0.086**				
		(0.036)				
Post × log(Police Activism)			-0.001			-0.001
			(0.003)			(0.003)
Post × log(Ration Shop Activism)				0.003		0.004
				(0.006)		(0.006)
Post × log(Food Distribution Activism)					-0.025***	-0.025***
					(0.005)	(0.005)
Post × log(District population)	0.153***	0.133**	0.157***	0.157***	0.160***	0.160***
	(0.056)	(0.058)	(0.056)	(0.056)	(0.056)	(0.056)
Post × log(State Area)	-0.023	-0.007	-0.049***	-0.050***	-0.050***	-0.050***
	(0.020)	(0.022)	(0.018)	(0.018)	(0.018)	(0.018)
Post × Nightlight	0.002	0.002	0.004	0.004	0.004	0.004
	(0.008)	(0.008)	(0.008)	(0.008)	(0.008)	(0.008)
Post × log(Migrants)	-0.025	-0.001	-0.027	-0.029	-0.031	-0.031
	(0.054)	(0.056)	(0.054)	(0.054)	(0.054)	(0.054)
Post × log(Inter-State Migrants)	-0.013	-0.012	-0.023	-0.023	-0.022	-0.022
	(0.016)	(0.016)	(0.016)	(0.016)	(0.016)	(0.016)
Post × log(Number of Ration Cards)	-0.011	-0.023	-0.003	-0.003	-0.000	0.000
	(0.017)	(0.017)	(0.017)	(0.017)	(0.017)	(0.017)
Start Subdistrict FE	Yes	Yes	Yes	Yes	Yes	Yes
Date FE	Yes	Yes	Yes	Yes	Yes	Yes
Adjusted R_2	0.184	0.184	0.183	0.183	0.183	0.183
Observations	116,690	116,690	116,690	116,690	116,690	116,690

Note: Standard errors in parentheses are clustered at the subdistrict-subdistrict dyad level. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

Table S7. Inter-State Portability and Mobility

Panel A. Summary Statistics and Correlation Matrix (N = 12,934)

	Variable	Mean	S.D.	Min	Median	Max	1	2	3	4	5	6	7	8	9	10	11	12	13
1	*Inter-State Mobility*	102.40	510.90	10	47	30519	1												
2	*Post*	0.50	0.50	0	1	1	-0.04	1											
3	*Starting State Inter-State Portability*	0.64	0.48	0	1	1	0.04	-0.01	1										
4	*Ending State Inter-State Portability*	0.49	0.50	0	0	1	-0.05	0.00	0.16	1									
5	*Police Activism*	80.67	73.80	0	67	389	0.01	0.37	0.23	0.18	1								
6	*Ration Shop Activism*	0.49	0.99	0	0	5	-0.02	0.49	0.05	0.01	0.15	1							
7	*Food Distribution Activism*	1.21	2.65	0	0	24	-0.02	0.31	0.05	0.12	0.20	0.04	1						
8	*District Population (million)*	2.69	2.13	0.05	2.22	11.06	-0.01	-0.23	0.19	0.18	0.15	-0.08	0.03	1					
9	*State Area (thousand km2)*	157.00	108.80	0.11	130.10	342.20	-0.06	-0.07	0.48	0.40	0.14	-0.01	0.10	0.30	1				
10	*Nightlight*	3.23	5.20	0.38	1.53	33.53	0.05	-0.22	0.09	0.01	0.02	-0.11	-0.06	0.63	0.01	1			
11	*Migrants (million)*	0.90	0.92	0.01	0.65	6.30	0.00	-0.25	0.22	0.17	0.18	-0.11	0.02	0.95	0.30	0.64	1		
12	*Inter-State Migrants (million)*	0.20	0.38	0.00	0.09	2.62	0.04	-0.20	0.23	0.02	0.13	-0.09	-0.02	0.75	0.17	0.77	0.84	1	
13	*Number of Ration Cards (million)*	9.72	8.80	0.02	9.32	56.35	-0.05	-0.02	-0.11	0.13	0.06	0.05	0.06	0.30	0.29	0.01	0.21	0.06	1

Note: This table pertains to *inter-state* analysis, including all the subdistrict dyads that are between two different states. This table is different from Table S2, which pertains to intra-state analysis. Movement data is at the state-state dyad level.

Table S7. Inter-State Portability and Mobility

Panel B. Inter-State Portability, Local Institutional Activism, and Inter-State Mobility

Dependent Variable	*log(Inter-State Mobility)*				
	(1)	(2)	(3)	(4)	(5)
Post × *Starting State Inter-State Portability*	0.010				
	(0.071)				
Post × *Ending State Inter-State Portability*	0.073				
	(0.074)				
Post × *log(Police Activism)*		-0.000			-0.000
		(0.008)			(0.008)
Post × *log(Ration Shop Activism)*			-0.016**		-0.016**
			(0.007)		(0.007)
Post × *log(Food Distribution Activism)*				0.009	0.006
				(0.011)	(0.011)
Post	-0.144	-0.130	-0.123	-0.138	-0.126
	(0.317)	(0.326)	(0.320)	(0.321)	(0.325)
Post × *log(District population)*	0.303*	0.286*	0.284*	0.286*	0.284*
	(0.165)	(0.163)	(0.163)	(0.163)	(0.163)
Post × *log(State Area)*	-0.043	-0.035	-0.035	-0.035	-0.034
	(0.059)	(0.054)	(0.054)	(0.054)	(0.054)
Post × *Nightlight*	-0.008	-0.008	-0.008	-0.008	-0.008
	(0.016)	(0.016)	(0.016)	(0.016)	(0.016)
Post × *log(Migrants)*	-0.368**	-0.337**	-0.331**	-0.337**	-0.331**
	(0.155)	(0.152)	(0.152)	(0.152)	(0.152)
Post × *log(Inter-State Migrants)*	0.135**	0.126**	0.124**	0.125**	0.123**
	(0.054)	(0.054)	(0.054)	(0.054)	(0.054)
Post × *log(Number of Ration Cards)*	0.014	0.013	0.013	0.012	0.012
	(0.050)	(0.050)	(0.050)	(0.050)	(0.050)
Start Subdistrict FE	Yes	Yes	Yes	Yes	Yes
Adjusted $R2$	0.336	0.336	0.336	0.336	0.336
Observations	12,934	12,934	12,934	12,934	12,934

Note: Standard errors in parentheses are clustered at the subdistrict-subdistrict dyad level. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

Table S8. Distribution of Intra-State and Inter-State Mobility Observations by Date

Panel A. Distribution of Mobility Observations by Date

	Intra-State		Inter-State	
Date	Freq.	Percent	Freq.	Percent
19mar2020	14,185	12.16	2,194	16.96
20mar2020	13,978	11.98	2,126	16.44
21mar2020	13,832	11.85	2,096	16.21
25mar2020	7,446	6.38	658	5.09
26mar2020	7,436	6.37	653	5.05
27mar2020	7,440	6.38	641	4.96
28mar2020	7,368	6.31	651	5.03
29mar2020	7,101	6.09	632	4.89
30mar2020	7,709	6.61	654	5.06
31mar2020	7,593	6.51	653	5.05
01apr2020	7,542	6.46	673	5.20
02apr2020	7,425	6.36	651	5.03
03apr2020	7,635	6.54	652	5.04
Total	116,690	100.00	12,934	100.00

Table S8. Distribution of Intra-State and Inter-State Mobility Observations by Date

Panel B. Distribution of Mobility Observations by Starting State

	Intra-State (Inter-Subdistrict)		Inter-State	
Starting State	**Freq.**	**Percent**	**Freq.**	**Percent**
Andhra Pradesh	6,511	5.58	1,012	7.82
Arunachal Pradesh	372	0.32	153	1.18
Assam	3,823	3.28	410	3.17
Bihar	11,897	10.2	1,053	8.14
Chhattisgarh	2,157	1.85	137	1.06
Daman & Diu	0	0	147	1.14
Goa	329	0.28	37	0.29
Gujarat	11,810	10.12	378	2.92
Haryana	3,228	2.77	1,655	12.8
Himachal Pradesh	3,261	2.79	546	4.22
Jammu & Kashmir	472	0.4	76	0.59
Jharkhand	4,320	3.7	683	5.28
Karnataka	5,166	4.43	847	6.55
Kerala	3,762	3.22	301	2.33
Madhya Pradesh	10,344	8.86	1,039	8.03
Maharashtra	13,573	11.63	1,200	9.28
Manipur	352	0.3	14	0.11
Meghalaya	185	0.16	41	0.32
Mizoram	241	0.21	3	0.02
Nagaland	326	0.28	99	0.77
Odisha	6,829	5.85	408	3.15
Punjab	4,385	3.76	613	4.74
Rajasthan	12,661	10.85	1,173	9.07
Tamil Nadu	5,043	4.32	594	4.59
Tripura	311	0.27	9	0.07
West Bengal	5,332	4.57	306	2.37
Total	**116,690**	**100**	**12,934**	**100**

Table S9. List of Newspapers and Periodicals Used in Coding Activism by Police, Local Ration Shops and Civil Society Food Distribution Actors

Accommodation Times (India)	Manorama Online (Kerala, India)	The Hindu Online (India)
Afternoon Voice (Mumbai)	Mathrubhumi (Kerala, India)	The Hitavada (India)
Ahmedabad Mirror (India)	Meghalaya Times (India)	The Milli Gazette (India)
Assam Times (India)	Metro Vaartha (Kerala, India)	The New Indian Express (Chennai)
Assam Tribune (India)	Mid Day (India)	The New Nation (Bangladesh)
Bangalore Mirror (India)	Millennium Post (New Delhi, India)	The Pioneer (India)
Business Standard (India)	Mint (India)	The Saptahik Samaya (India)
BusinessLine (The Hindu) (India)	Mumbai Mirror	The Sentinel (India)
BusinessLine Online (India)	Munsif Daily (India)	The Star of Mysore (India)
Central Chronicle (India)	Navhind Times (Panaji, India)	The Statesman (India)
Daily Excelsior (Jammu, India)	New Indian Express	The Sunday Guardian (India)
Daily Post (Chandigarh, India)	NewKerala.com (India)	The Sunday Standard (New Delhi, India)
Deccan Chronicle (India)	Odisha Sun Times (India)	The Telegraph (India)
Deccan Herald (India)	Political & Business Daily (India)	The Times of India
DT Next (Chennai, India)	Projects Monitor (India)	The Times of India - Ahmedabad Edition
EXIM India (Mumbai)	Pune Mirror (India)	The Times of India - Bangalore Edition
Financial Chronicle (India)	Sakaal Times (Pune, India)	The Times of India - Chandigarh Edition
Financial Express (India)	Sakshi Post (India)	The Times of India - Chennai Edition
Financial Express Online (India)	Sangai Express (Manipur, India)	The Times of India - Delhi Edition
Free Press Journal (Mumbai)	Siasat Daily (India)	The Times of India - Hyderabad Edition
Garhwal Post (India)	Star of Mysore (India)	The Times of India - Jaipur Edition
Herald (Goa, India)	Telangana Today (India)	The Times of India - Kochi Edition
Hindustan Times (India)	The Asian Age (India)	The Times of India - Kolkata Edition
HT Columnists (India)	The Economic Times - Bangalore Edition (India)	The Times of India - Lucknow Edition
Indian Express	The Economic Times - Delhi Edition (India)	The Times of India - Mumbai Edition
Indian Express Online	The Economic Times - Kolkata Edition	The Times of India - Pune Edition
Jagran English (India)	The Economic Times - Mumbai Edition	Udayavani (Manipal, India)
Jagran Post (India)	The Economic Times (India)	Voice of Sikkim (India)
Kaumudi Online (Kerala, India)	The Hans India (Andhra Pradesh)	
Mail Today (New Delhi, India)	The Hindu (India)	

Table S10. Ranking of Words Similar to "ration" in News Articles

These words are ranked by descending product of similarity as measured by dot product of relevant vectors.

Original Word Root	**Similar Word Root (Stemmer)**	**Similarity**
ration	Shop	0.731
ration	Distribute	0.713
ration	Card	0.682
ration	Holder	0.655
ration	Free	0.655
ration	Rice	0.625
ration	Cardhold	0.621
ration	Pd	0.620
ration	Subsidis	0.609
ration	beneficiari	0.608
ration	elig	0.577
ration	nonprior	0.565
ration	system	0.555
ration	provis	0.551
ration	token	0.549
ration	fair	0.543
ration	white	0.538
ration	quota	0.537
ration	advanc	0.536
ration	monthli	0.532

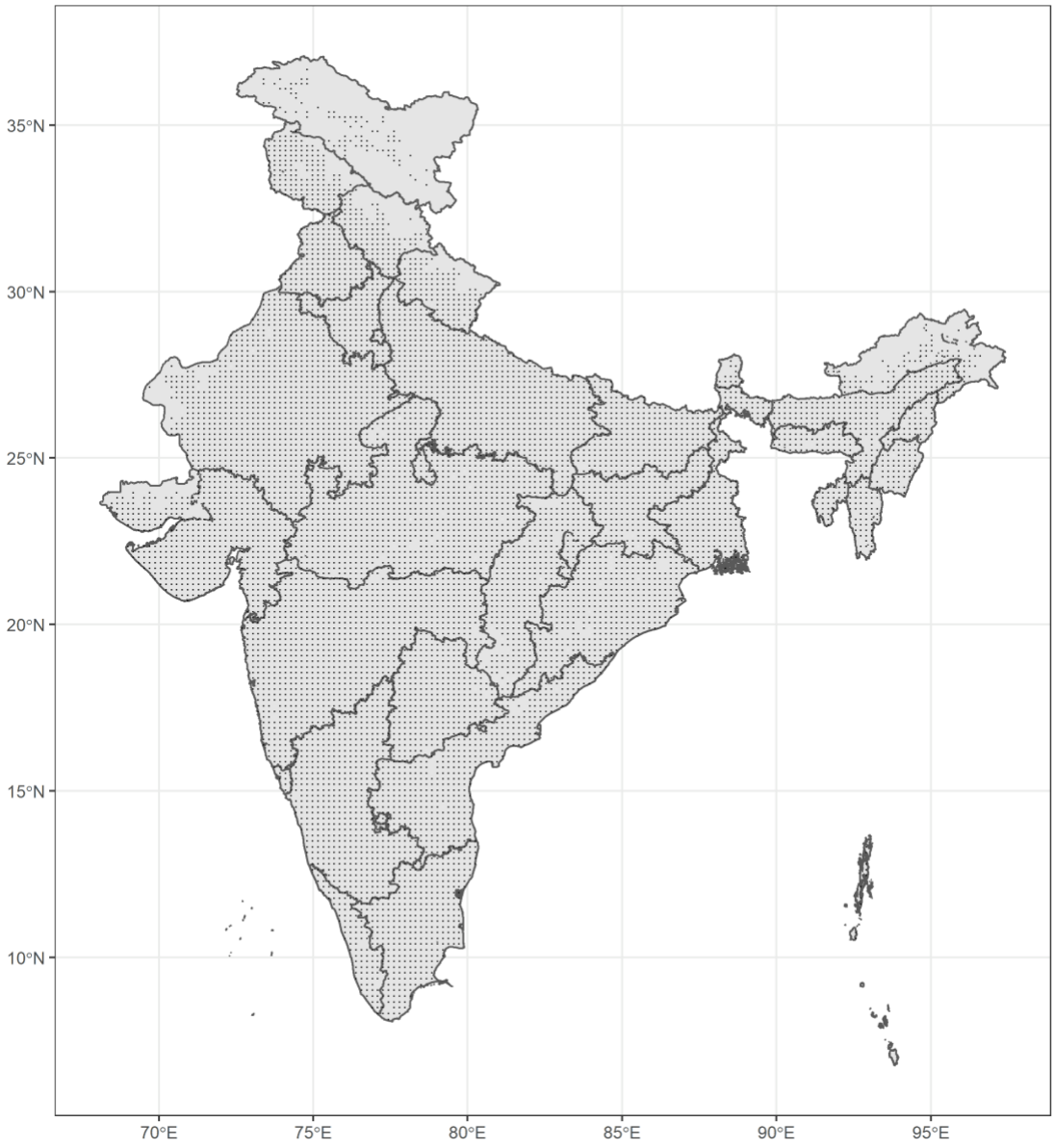

Figure S1. Centroids of Mobility Data (Zoom Level 11)

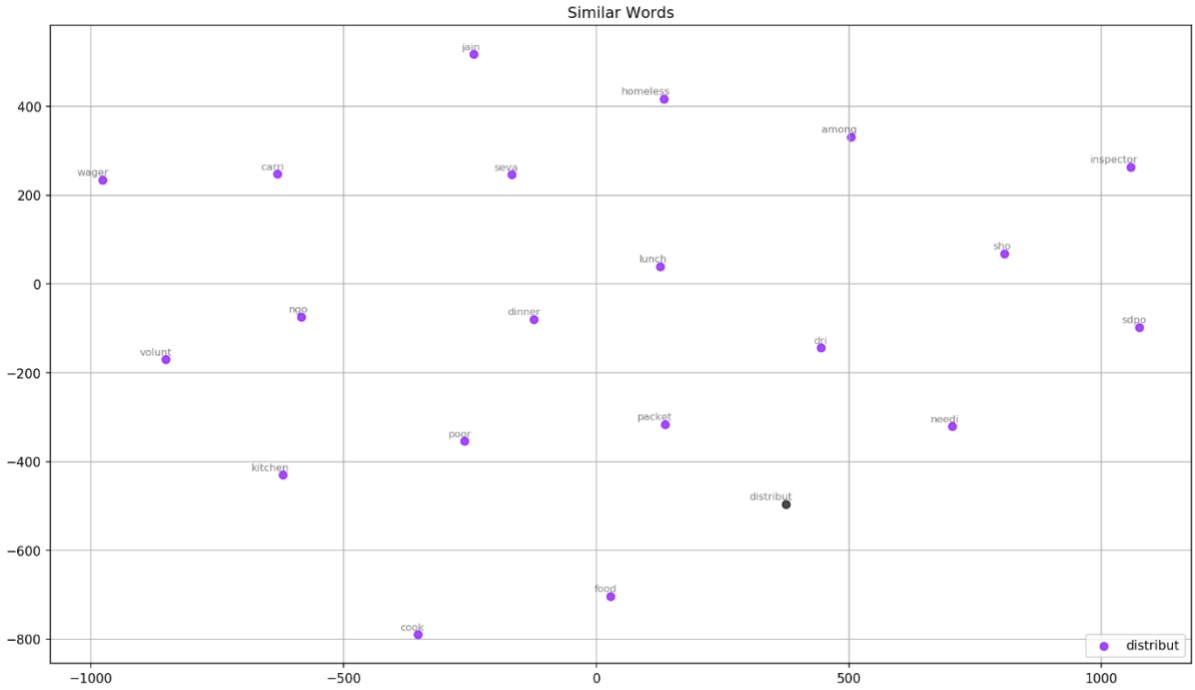

Figure S2a. Two-dimensional projection of words similar to "distribute" in periodicals

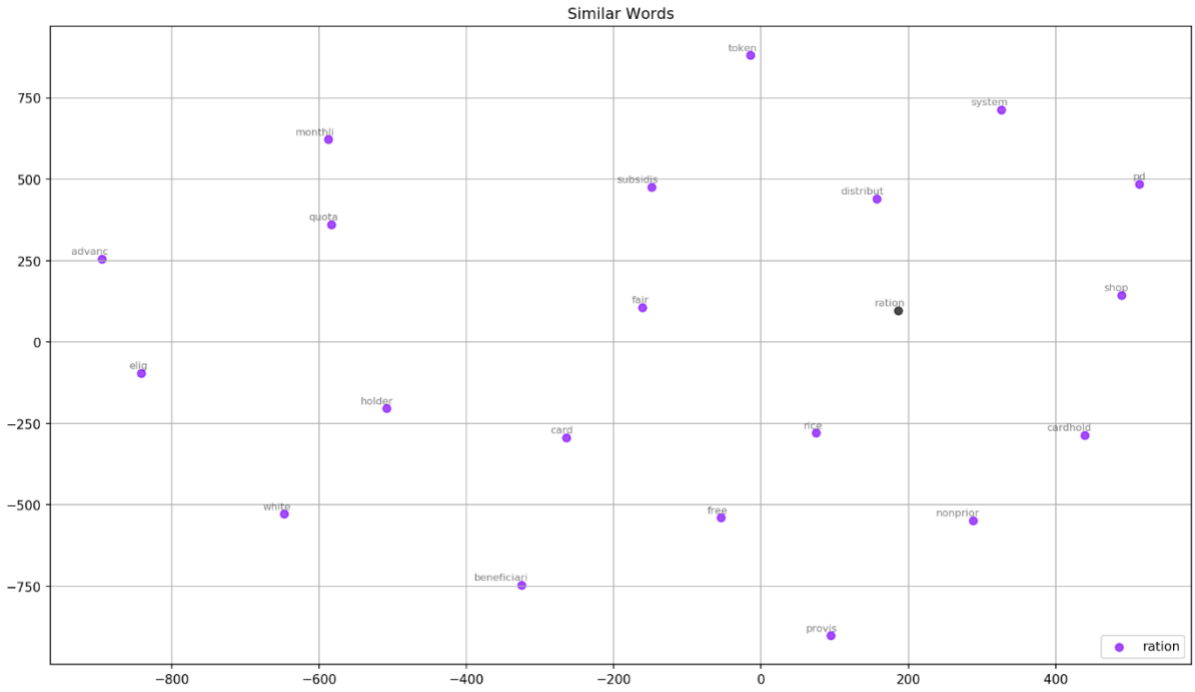

Figure S2b. Two-dimensional projection of words similar to "ration" in periodicals

Figure S2. Word Similarity from Machine Learning

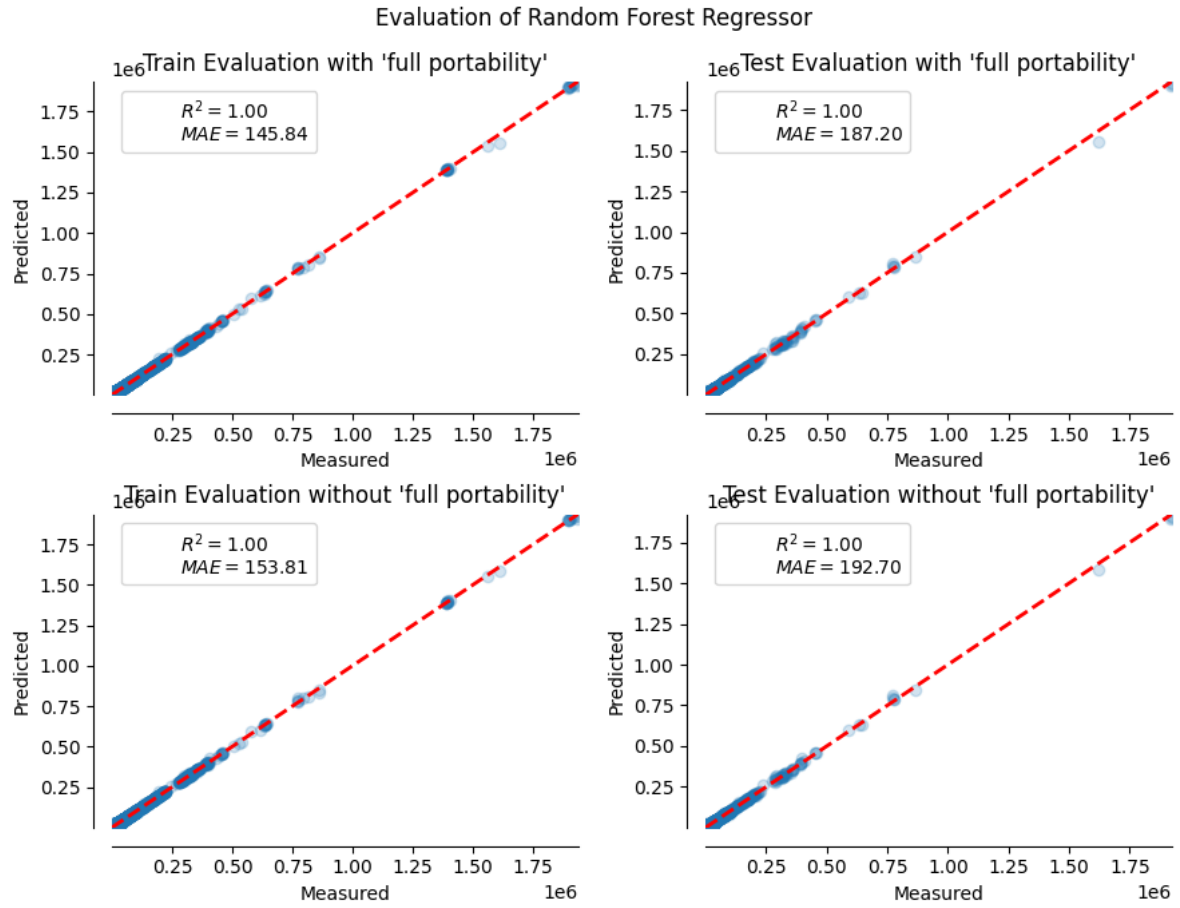

Figure S3: Robustness Check using Random Forest Machine Learning Model

To test for the robustness of the effect of portable states in reducing intra-state mobility, a Random Forest Regressor was used for a given regression problem. We ran two sets of predictions and in both sets we included all relevant predictors with a key difference: in only one of the datasets we included the variable related to whether or not the state had full intrastate portability of ration cards (dataset X1). In other words, the second dataset (X2) was identical to X1 but in X2, we dropped the predictor related to whether or not the state had full intrastate portability of ration cards (referred to as "*full portability"* in the figure). The response variable was intra-state moments on each day for the state. The given datasets were split into training dataset and test dataset with a standard 80-20 split (80 for train and 20 for test). To find the best hyperparameter values for a) number of trees in the forest and b) maximum depth of the trees , we ran a grid search using 10-fold cross validation using these combinations: number of trees = (10, 50, 100, 500) maximum depth = (3, 4, 5, 6, 7, 8, 9, 10, 11, 12). For both X1 and X2 the best value for maximum depth was found to be 10 and the number of trees also to be 10. After that, we trained the Random Forest model on the complete X1 training dataset and tested on the X1 test dataset. The same experiment was done with the X2 dataset.

For the X1 test dataset, the mean absolute error (MAE) was found to be 187.20 and the R_2 (Coefficient of Determination) was found to be 1.00. Similarly, for the X1 train dataset, the MAE was found to be 145.84 and the R_2 (Coefficient of Determination) was found to be 1.00. For the X2 test dataset, the MAE was found to be 192.70 and the R_2 (Coefficient of Determination) was found to be 1.00. Similarly, for the X2 train dataset, the MAE was found to be 153.81 and the R_2 (Coefficient of Determination) was found to be 1.00. Collectively, these results indicate that the MAE decreased after including *full portability* in both train and test datasets, suggesting that the predictor *full portability* is a valid predictor for intra-state mobility.

Anecdotal Evidence

To quote a popular press report, the portability policy permits one to purchase only half the subsidized grains at one time in an effort to prevent one member of the household taking the entire ration for the month, leaving family members in a different location stranded without food (25). To resolve this issue, it requires a significant amount of coordination between different state, district, and subdistrict governments. Additionally, in states such as Jharkhand, there is a large number of pending ration card applications, implying that migrants from these states are excluded from the 'One nation, one ration card' policy. In Uttar Pradesh, the government has provided food to 35,843 beneficiaries of the Antyodaya scheme, which seeks to provide food to the poorest of the ration card holders (27). Another directive from the District Magistrate of the *Purba Bardhaman* district in West Bengal ensures that all citizens with pending ration card applications get access to subsidized food (28). These examples show that there is substantial variation in how rationing is conducted at the local level by local governments, ration shops, and other stakeholders might

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