TRAJECTORY OF COVID-19 IMPACTS ON FOOD SECURITY IN ETHIOPIA: A PANEL DATA APPROACH

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Abstract

COVID-19 affects food security of households through different pathways. Studies from developing countries show that the pandemic had heterogeneous impacts on food security across various groups of households. This study aims to examine the trajectory of and differential impacts of the early days of the pandemic on food security in Ethiopia along households' location, ownership of assets and varying livelihoods and income sources. Using the World Bank's harmonized panel data on households drawn from the high frequency phone survey, the study undertakes fixed effects regressions. The results indicated that COVID-19 pandemic had a statistically significant impact, but a declining trend, on overall food insecurity in Ethiopia. Households in urban areas have faced a higher chance of being severely food insecure than those in rural, while those households that rely more on the agriculture have a lower odds of being food insecure. Ownership of livestock decreases probability of being severely food insecure. Besides, households whose income source was rental and wage employment were significantly exposed to food insecurity due to the pandemic. Moreover, the results identified significant heterogeneity of the impacts between households with and without receiving remittance and assistance. This suggests the important role of social protection in guarding households from food insecurity during the pandemic in the short term. Overall, the paper determined that living in rural/urban, ownership of land and livestock, rental income, remittance, assistance and wage employment are statistically significant indicators of heterogeneity in the pandemic's impacts on food insecurity.

Keywords: *COVID-19 pandemic; Impacts; Food insecurity; Heterogeneity; Trajectory.*

INTRODUCTION

The COVID-19 pandemic brings an unprecedented social and economic disruption in the world. One of the most striking observations during these difficult times has been the extremely diverse performance across countries in containing the pandemic and the economic outcomes that have ensued (Penas et al., 2022). Amare et al. (2020) indicated that the World Bank had forecasted that COVID-19 pandemic was highly likely to push more than 49 million people into extreme poverty in 2020 and beyond. Among this figure, greater than 45 % of these people are in Sub-Saharan Africa, implying that the region would be hit hardest in terms of increased extreme poverty. The World Food Programme (WFP) had estimated that the number of people globally facing acute food insecurity would almost double by the end of 2020 (about 135 million people before the crisis), due to income and remittance losses, and disruption

of food systems associated with the pandemic (WFP, 2020a, 2020b).

COVID-19 could affect food security of households through different pathways. For instance, lockdowns and social distancing measures can adversely affect incomes by reducing economic and livelihood activities, which directly affect food security. Several studies in different countries show that the pandemic has had heterogeneous impacts on various livelihood options and sectors (Amare et al., 2020). For instance, livelihoods and sectors that can operate on a remote basis with limited personal interactions or those functionally dependent on the internet are likely to be less affected, relative to those involving personal interactions (Abay et al., 2020). Similarly, some livelihood options and sectors are likely to experience a relatively higher disruption in economic activities. For instance, government-imposed mobility restrictions and shutdowns often disrupt supply chains, which may prove the most challenging for small businesses with smaller stock. Thus, those households relying on non-farm business activities are likely to experience disproportionally higher impacts associated with disruptions in value chains caused by the pandemic and related mobility restrictions (Amare et al., 2020).

Immediately after the first COVID-19 case was observed in mid-March 2020 in Ethiopia, the government of Ethiopia has put in place a range of measures to mitigate the economic impact of the COVID-19 pandemic, while aiming at containing transmission. Right after the first few cases of COVID-19 were detected, the government implemented a state of emergency, and adopted a comprehensive COVID-19 national emergency response plan to ensure that efforts to fight the crisis are comprehensive and well-coordinated. Specifically, it implemented surveillance at borders, conducted contact tracing, established designated quarantine facilities, ensured the supply of drugs and protective equipment, and embarked on several communication efforts to raise awareness on how to deal with the virus (Batana et al., 2021).

Also, the government has taken various measures in order to contain the transmission of the pandemic. It put measures such as restrictions within country travel, restriction on international travel, limit on social gatherings, curfew or lockdown, closure of non-essential businesses, and closure of schools and universities, among others. To mitigate impacts on people and firms, authorities announced several economic measures, including additional expenditure on healthcare, provision of emergency food to the vulnerable, tax and social security payment deferrals, and liquidity injections and extension of forbearance measures in the financial sector (Bundervoet et al., 2021).

The COVID-19 pandemic has brought devastating economic impacts to low - and middle - income countries. The containment measures implemented by the

governments to prevent the spread of the virus, such as the orders of lockdowns, the closure of non-essential businesses, and social distancing, have resulted in employment and income loss among people with limited coping strategies. Moreover, COVID-19 exacerbated existing inequalities and those who were disadvantaged before the pandemic, such as women, youth, and low-skilled workers, have experienced even greater challenges (Bundervoet et al., 2021).

According to (WFP, 2020a) cited in Amare et al. (2020), these lockdowns and restrictions are expected to disrupting food supply chains and community services, and social protection programs, which ultimately positively affect food prices. Decreased import of basic stuffs due to restriction of international travel could raise process and be an added financial burden that directly affects food security of households. Besides, the same study mentioned that national and state-level restrictions and lockdowns would affect food transportation within the country, with clear implications on food supply and consequently, on food prices. Obviously, this would bring significant repercussions on food insecurity in the country, particularly in poorer and vulnerable urban households (Amare et al., 2020).

One of the most salient features of the economic impacts of the pandemic and respective policy interventions is the asymmetry along several dimensions. The actions taken by agents and policymakers have resulted in very different economic effects across sectors and regions (Cerezo et al., 2021). Studies have revealed that the impacts of the pandemic on household incomes, food security and welfare have been uneven across space, gender, livelihood options. It has been widely observed that the pandemic more severely affected urban households, many of whom are informal, self-employed, or casual workers, in many low- and medium-income countries (Batana et al., 2012; Bundervoet et al., 2021). In Uganda and Kenya, economic effects of such a pandemic disproportionately impact members of the society, depending on their socio-economic status, livelihood strategies, access to markets, etc. Thus, it is important to understand the household level impacts and support mechanisms that can be enhanced to ensure income smoothing (Kansiime et al., 2021).

In Ethiopia, the COVID-19 pandemic has affected economic activity with significant adverse effects on employment, particularly at the onset of the pandemic (Batana et al., 2021). The same study has also shown the existence of spatial heterogeneity on impacts of COVID-19, in which households in large towns faced a higher chance of reduced labor incomes. The pace of recovery among female-headed households has been slow in terms of labor incomes, particularly in large towns. The study has also mentioned that self-employed households experienced severe income loss in earlier rounds, but they recovered fast in terms of the probability of further reducing labor incomes both in small and large towns. Also, poor Ethiopian households experienced severer income shocks in the early rounds, and those in larger towns still had a higher probability of income loss even in the future.

Ravallion et al. (2020) also argued that the pandemic is likely to disproportionately exacerbate food insecurity in those areas or household with preexisting vulnerabilities to food security likely to be magnified. Impacts are expected to be most severe for poorer households in both rural and urban areas (Ravallion et al., 2020). Additionally, the impact is expected to vary across livelihood options, with those activities that require face-to-face interactions likely to experience a significant loss in demand (Abay et al., 2020; Amare et al., 2020). Furthermore, value chain disruptions may extend deeply into rural areas, affecting both input supply and output demand for farming households and affecting the income of those employed in both forward and backward agricultural value chains (Amare et al., 2020; Reardon et al., 2020a). As cited in Amare et al.(2020), Barrett (2020) and Devereux et al. (2020) mentioned that closure or disruption of informal food markets, where the poor obtain the majority of their food, may be more severe in extent and food security impacts.

Beside the limited number of studies conducted in Ethiopia on the impacts of the pandemic, those available are skewed to analyzing its household level income and macroeconomic effects. Also, less is known about the asymmetric effects of the pandemic on Ethiopian households' food security situations. It is, therefore, against to these background that this study is motivated. It intends to shed light on the issue using a household level survey panel data. In particular, the paper aims to explore the potential heterogeneity in the impacts of COVID-19 on households' food security in Ethiopia along various socioeconomic characteristics of households and location dimensions. It also aims to examining the trajectory of the impacts of COVID-19 pandemic on households' food security situation in Ethiopian.

LITERATURE REVIEW

Since the onset of the COVID-19, many researches have been conducted and published on the multi-dimensional impact of the disease in the developed and developing countries. For the purpose of substantiating the rational of making this study and also informing development of methodology for this study, a brief review of few empirical literatures on the impacts of the pandemic at international, regional and national level is conducted.

Bundervoet et al. (2021) combines data from high-frequency surveys with data on the stringency of containment measures to examine the short-term impacts of the COVID-19 pandemic on households in developing countries. Using data from 34 countries, it runs logistic regressions of four main indicators (stop working, income loss, food insecurity, or continued learning) on a set of explanatory variables and country or region dummies. The findings show that in the average country, 36% of respondents stopped working in the immediate aftermath of the pandemic, over 64% of households reported decreases in income, and over 30% of children were unable to

continue learning during school closures. Pandemic-induced loss of jobs and income translated into heightened food insecurity at the household level. The same study mentioned that the pandemic's effects were widespread and highly regressive, disproportionally affecting vulnerable segments of the population. It asserts the existence of heterogeneous impacts of the pandemic across women, youth, and lower-educated workers, who are significantly more likely to lose their jobs and experience decreased incomes. Self-employed and casual workers bore the brunt of the pandemic-induced income losses.

Using China's household finance survey data, Liu et al. (2020) explored the impact of COVID-19 on Chinese household consumption through ordinary least square (OLS) method. Several household and individual level control variables are included in the estimation. To capture the impact of inherent differences or heterogeneity (such as cultural environment, regional consumption habits, and savings preferences) at the regional level on household consumption, the study controlled for the city-level fixed effect. It finds that there was a significant decline in household consumption during the outbreak period. Heterogeneity analysis shows that the pandemic suppresses consumption in urban households, and rural households are, however, less affected.

Through a computable general equilibrium model-based simulation, Kabir et al. (2021) assesses the gender dimensions of the impact of COVID-19 on economic outcomes, that is, labor force participation, employment, wages, and earnings. Using the 2020 high-frequency phone survey in Chad, the study applied a probit model to determine if differences in income reduction exist between female and male-headed households. It finds that the COVID-19 pandemic brings disproportionately higher negative impact on women in urban areas. The situation is potentially dire, especially in service sectors, where most women are employed in urban areas. Moreover, the pandemic has notably impacted the households' income from enterprises and suggests that this negative impact is more prevalent for female-headed households. Female-headed households in rural and urban areas have been more reliant on aid from family and friends and less reliant on savings, credit, or the sale of assets.

Consolazio et al. (2021) assessed the role of five area level indicators in shaping the risk of contagion in the provinces of Milan and Lodi (Lombardy, Italy), namely: educational disadvantage, unemployment, housing crowding, mobility, and population density. Data on COVID-19 patients from the integrated data warehouse were used and matched with aggregate-level data from the National Institute of Statistics. Multilevel logistic regression models were used to estimate the association between the census block-level predictors and COVID-19 infection, independently of age, sex, country of birth, and preexisting health conditions. All the variables were significantly associated with the outcome, with different effects before and after the lockdown and according to the province of residence. This suggests a pattern of socioeconomic inequalities in the outbreak, which should be taken into account in the

eventuality of future epidemics to contain their spread and its related disparities.

In Africa, Kansiime et al. (2021) assessed implications of COVID-19 pandemic on household income and food security in two East African countries (Kenya and Uganda). Using the Food Insecurity Experience Scale (FIES) to measure food security, the study has fitted probit model to estimate the factors determining whether a respondent's source of income has been affected by the COVID-19 crisis and whether food and nutrition outcomes have worsened during the pandemic. The results show that more than 66% of the respondents experienced income shocks. Food security and dietary quality worsened. Income-poor households and those dependent on labour income were more vulnerable to income shock, and had poorer food consumption during the COVID-19 pandemic compared to others. Farmers were less likely to experience worsened food security. Membership in savings and loan group reduces the likelihood of suffering income shocks and reduction in food consumption (Kansiime et al., 2021).

Additionally, Josephson et al. (2020) has applied reduced-form econometric methods to longitudinal household survey data from Ethiopia, Malawi, Nigeria, and Uganda, organized from the pre- COVID-19 face-to-face household surveys and from the novel phone surveys conducted during the pandemic. It has indicated that around 256 million individuals, about 77% of the population in the four countries, were estimated to live in households that have lost income due to the pandemic. Secondly, attempts to cope with this loss were exacerbated by the inability to access medicine and staple foods among 20 to 25 % of the households in each country. Finally, it has mentioned that food insecurity is disproportionately borne by households that were already impoverished prior to the pandemic.

Furthermore, Bukari et al. (2021) examined the effect of COVID-19 on poverty and living standards of households in Ghana. Using data on 3,905 households that were obtained via concurrent online survey and telephone interviews, it has run ordinary least squares, probit model and simultaneous quantile regressions. Results showed that COVID-19 had significantly increased the poverty levels of households while deteriorating living standards. It has also discovered that gender and locational heterogeneities exist regarding the impact of COVID-19 with females and rural dwellers mostly disadvantaged. However, in terms of overall household consumption, those in the middle and upper classes are profoundly affected compared to those in the lowest quintile.

Likewise, a study by Amare et al. (2020) combines pre-pandemic face-to-face survey data with follow up phone surveys collected in April-May 2020 to quantify the overall and differential impacts of COVID-19 on household food security, labor market participation and local food prices in Nigeria. The study exploited spatial variation in

exposure to COVID-19 related infections and lockdown measures along with temporal differences using a difference-in-difference approach. It found that households exposed to higher COVID-19 cases or mobility lockdowns experience a significant increase in measures of food insecurity. Also, it indicated that COVID-19 significantly reduces labor market participation and increases food prices, and the impacts differ by economic activities and households, while the lockdown measures have smaller impacts on wage-related activities and farming activities. In terms of food security, households relying on non-farm businesses, poorer households, those with school-aged children, and those living in remote and conflicted-affected zones have experienced relatively larger deteriorations in food security.

In Ethiopia, Beyene et al. (2020) examined the potential economy-wide impacts of the COVID-19. The study has used a dynamic computable general equilibrium model calibrated to a social accounting matrix for 2010/11 and covered the period from 2010/11 to 2029/30. The analysis accounts for the main channels through which the COVID-19 affects the economy. The domestic transmission channels include reduced labor market participation, lower productivity, and rising domestic trade costs. External channels include higher international trade costs, a drop in export demand, lower import supply, a reduction in foreign direct investment (FDI), reduction in remittances, and lower import price of oil. It has analyzed the impact of the COVID-19 crisis using three scenarios, namely business as usual, and the COVID-19 scenario considered under mild and severe assumptions. Economic impacts are expected to have differentiated impacts on a wide range of economic and social indicators. The pandemic is likely to have significant growth and welfare effects even under an optimistic scenario of mild shock and quick recovery. Employment is likely to be hardly hit. Although there is much uncertainty in the future, the COVID-19 crisis is likely to have medium-to-long-term negative effects. GDP growth rate is expected to converge to the no-COVID-19 baseline relatively swiftly if the scope of the shock is mild. However, the GDP and welfare losses are not likely to be fully recovered. In an amplified scenario, the economic and welfare losses would be higher and the gap with the no COVID-19 baseline would be much greater (Beyene et al., 2020).

Additionally, Batana et al. (2021) studied the existence of spatial heterogeneity in the impacts of the early days of the COVID-19 pandemic on urban household incomes in Ethiopia and Kinshasa, Democratic Republic of Congo. Combining new panel household surveys with spatial data, the fixed-effects regression analysis for Ethiopia finds that households in large and densely populated towns were more likely to lose their labor incomes in the early phase of the pandemic, and their recovery was slower than other households. Disadvantaged groups, such as female, low-skilled, self-employed, and poor, particularly suffered in those towns. In Kinshasa, labor income-mobility elasticities are higher among workers—particularly female and/or low-skilled workers—who live in areas that are located farther from the city core area or highly dense and precarious neighborhoods. The between- and within-city evidence

from two Sub-Saharan African countries points to the spatial heterogeneity of COVID-19 impacts, implying the critical role of mobility and accessibility in urban agglomerations.

On the other hand, a research report by Hirvonen (2020) at IFPRI suggests that the pandemic has not led to unusually large increases in food prices. However, a case study in the vegetable sector suggests that price dynamics are highly context and crop specific, calling for more comprehensive price monitoring to identify food value chains and areas where food price increases may have been unusually rapid. Second, employment losses have concentrated on informal sector workers while redundancies in the formal sector have been less significant. Third, there is considerable uncertainty about the income, poverty, and food security implications of this crisis. While most households report income losses, the qualitative and subjective nature of these questions mean that the magnitudes of these losses are unknown. In Addis Ababa, less subjective food security measures indicate only small negative changes in household food and nutrition security. Finally, the report mentioned that limited access to mobile phones in rural areas results in imperfect and incomplete information on how this crisis has been affecting rural households in Ethiopia.

At zonal level in Ethiopia, Asegie et al. (2021) has investigated the effect of COVID-19 on the livelihood activities of smallholder farm households located in South Wollo and Oromia Administrative Zones in Ethiopia. Primary data from 275 respondents were collected and binary logistic regression model run. The dependent variable is the household's livelihood status as a result of the COVID-19 pandemic, takes 1 if at least one livelihood activity was affected and 0, otherwise. The results showed that the lives and livelihoods impacts varied depending on geo-local settings and pre-pandemic livelihood activities of the target districts. It concluded that the pandemic significantly affected all dimensions of livelihood diversification strategies. Particularly non-farm and off-farm livelihood activities of smallholder farmers are significantly affected.

MATERIAL AND METHODS

Data Type, Source and Variables

The empirical analysis relies on a harmonized household phone surveys that have been collected since the outbreak of the COVID-19 pandemic in Ethiopia. The World Bank conducted a high frequency phone survey (HFPS) of households to monitor the economic and social impacts of and responses to the COVID-19 pandemic on households, and thus inform interventions and policy responses (Wieser et al., 2020). The HFPS builds on the national longitudinal Ethiopia Socioeconomic Survey (ESS) that the Central Statistical Agency (CSA) carried out in 2019 in collaboration with the World Bank. The HFPS drew a subsample of the ESS sample that was representative of households with access to a working phone. It is conducted by calling a sample of

households every three to four weeks for a total of 12 survey rounds, starting in April 2020.

Finally, from the HFPS of households, the World Bank has prepared a harmonized dataset in order to create a comparable picture of how the pandemic affects the live of the poor. Harmonized indicators help to track the impact of the pandemic and mitigating policies over time in a comparable manner. Since the outcome variable of this study, which is probability of being food insecure, is available only for five rounds (round 2 – 6) in the harmonized dataset for households in Ethiopia, the study uses a panel data organized from these five rounds only. The main advantage of using panel data is that it deals with time-invariant unobserved heterogeneity that causes bias in estimation if it is not accounted for.

Besides, the study exclusively focuses on household level characteristics as predictor and independent variables. Using the households' id and survey rounds as the main identifiers and following the required data management processes, a panel data of 14,506 observations have been employed. The analysis includes data on total household food insecurity situation, and various households' socioeconomic characteristics and location variables.

Outcome variables: (food insecurity indicators): Food security is measured using two separate, but not exclusive, variables on probability of food insecurity. They are the "probability of being moderately/severely food insecure >= 50%" and the "probability of being severely food insecure >= 50%". Each takes binary values, "1" if "yes" and "0" if "no". That means, if the probability of being food insecure is greater than or equal to 0.50 (>=50%), it takes 1 and 0 otherwise.

Explanatory variables and predictors: The independent variables for the study comprised household level characteristics only. The key indicator variables are sector or location of the the household, ownership of land, livestock, and non-farm family business enterprises, sources of livelihoods such as working in agriculture, wage employment, and income sources such as rent, remittance and assistance. Since they have time trend across the 5 rounds, as seen in the harmonized data by the world Bank, variables such as household size, change in household head, adult equivalence are included in the estimation as time-variant household characteristics in order to control their effects, if any.

TABLE 1. DESCRIPTIVE RESULTS OF KEY EXPLANATORY VARIABLES

No.	Variable	Obs.	Mean	Std. Dev.	Min	Max
1	Rural/Urban	14,506	1.70764	0.45486	1	2
2	Land Ownership	14,506	0.24025	0.42725	0	1
3	Rental income	14,506	0.09176	0.28869	0	1
4	Received remittance	14,506	0.17234	0.37769	0	1
5	Received assistance	14,506	0.05756	0.23292	0	1

6	Percentage of working adults working in agriculture	14,506	18.5313	33.6682	0	100
7	Percentage of working adults working in wage work	14,506	22.4807	34.0672	0	100
8	Ownership of livestock	14,506	0.35999	0.48001	0	1
9	Household head changed	14,506	0.00255	0.05044	0	1
10	Household size	14,506	4.37081	2.20392	1	14
11	Adult equivalence in the household	14,506	3.43859	1.75645	0.73	11.98
12	Household members above 65 & below 15 ages	14,506	1.70081	1.55624	0	9
13	Probability of being moderately / severely food insecure >= 50%	14,506	0.30360	0.45983	0	1
14	Probability of being severely food insecure >= 50%	14,506	0.04440	0.20598	0	1

Moreover, to better understand the differential impacts of the pandemic on households' food security, the study used baseline characteristics of households to differentiate those vulnerable households and livelihood activities. As the impacts of the pandemic are likely to vary across households, it aims to uncover heterogeneous impacts across various groups of households based on different dimensions. The variables for identifying the differential impacts are location (rural/urban), ownership of assets (land, and livestock), livelihood activities (agriculture, and wage employment); and income sources (rental income, remittance, and assistance).

The harmonized HFPS on households produced by the World Bank includes household characteristics of the baseline information from the national longitudinal Ethiopia Socioeconomic Survey (ESS) that the Central Statistical Agency (CSA) carried out in 2019 across the country. These data on household characteristics remain the same across all survey rounds. Only household size, adult equivalence and change in the household head vary across the rounds in the dataset. This makes the dataset more convenient and appropriate for analyzing the heterogeneous or differential impacts of COVID-19 across the different groups of households.

Table 2 below presents a simple descriptive indicator (percentage) of the probability of food insecurity of households in all rounds in different groups of households. From the total, 30.36% of the households asked in all rounds (column 1) have reported that they have faced a moderately/severely food insecurity during the pandemic, while the remaining 69.64% (column 2) didn't face such food insecurity problem. Only 4.44% of

the total households have faced severe food insecurity in the five rounds of the study period (column 3).

TABLE 2. PERCENTAGE OF FOOD INSECURITY PROBABILITIES BY GROUPS OF HOUSEHOLDS

		Probability of being moderately/ severely food insecure (P >= 50%)		Probability of being severely food insecure (P>= 50%)	
		Yes % (1)	No % (2)	Yes % (3)	No % (4)
Rural/Urban	Rural	11.43	17.81	1.72	27.51
	Urban	18.93	51.83	2.72	68.05
	Total	30.36	69.64	4.44	95.56
Ownership of land	Yes	21.76	54.21	2.96	73.01
	No	8.60	15.43	1.48	22.55
	Total	30.36	69.64	4.44	95.56
Ownership of livestock	Yes	16.19	47.81	2.23	61.77
	No	14.17	21.83	2.21	33.79
	Total	30.36	69.64	4.44	95.56
Rental income	Yes	28.60	62.23	4.23	86.59
	No	1.76	7.41	0.21	8.97
	Total	30.36	69.64	4.44	95.56
Received remittance	Yes	5.83	58.24	3.47	79.30
	No	24.53	11.40	0.97	16.26
	Total	30.36	69.64	4.44	95.56
Received assistance	Yes	27.55	66.70	4.09	90.16
	No	2.81	2.94	0.35	5.40
	Total	30.36	69.64	4.44	95.56

Source: Author's calculation from the harmonized HFPS data for Ethiopia.

Also, 11.43% and 18.93% of the total households surveyed in all rounds who have faced moderate or severe food insecurity are located in rural and urban areas respectively (column 1). From the total number of households surveyed in all rounds (14,506), different proportions who faced moderately/severely food insecurity (column 1) and those who have been exposed to severe food insecurity in different groups are given in column 3 of Table 2.

Analytical Method

The study aims to examine how the trajectory of COVID-19 food security shock varied by sector of households, ownership of assets, livelihood options and income sources in Ethiopia. Panel regression models are used to determine the dimensions/variables along which food security situations of households have differentially or heterogeneously been affected by the COVID-19 pandemic.

For such situations, the standard econometric methodology suggests the use of efficient panel data estimators, such as fixed effect and random effect estimators (Wooldridge, 2002). Fixed effect estimators control for unobserved time-invariant characteristics of households and account for within-household variations across time. Random effects model takes care of both within- and between-household variations. The Hausman test is applied to identify whether the fixed or random effect estimators

is better for the estimation. The regression equation is given by

$$y_{it} = \alpha + \beta_1 r_t + \beta_2 (r_t h_i) + \beta_3 x_{it} + \delta_i + \varepsilon_{it}$$

where, *y*it is a dummy variable for household i indicating the change in the probability of being moderately and/or severely food insecure (greater than or equal to 0.5) at round t since the previous survey round t-1; rt is a dummy indicator for the survey round; h_i indicates a characteristic of household i,; δ_i is a household fixed effect. Since h_i is a time-invariant variable (household characteristics), it is interacted with the round dummies. β_2 is the parameter of interest, indicating how the probability of households' food insecurity varies by the time-invariant characteristics (heterogeneity parameter). In addition, those time-variant household characteristics are controlled in x_{it}.

RESULTS AND DISCUSSIONS

The nature of the data and main objective of the research imply that the fixed effect (FE) is the appropriate method. The Hausman specification test also confirms that in all estimations the fixed effect model is better than the random effect model. So, the estimation results (coefficients and p-values) of the fixed effect model are used in the analysis and discussions below.

In this section, results on the impact of the pandemic on food security and associated heterogeneity factors are presented, corresponding to the model equation above. Estimation is made by interacting the round dummies with the time-invariant variables such as location of the households, ownership of land and livestock, sources of income (rent, remittance or assistance), and livelihood activities (agriculture and wage employment). The parameter associated with the round dummy captures aggregate trends in food security. It also captures aggregate potential differences in food security situations across the six survey rounds.

Both Table 3 and 4 present estimates of the parameter of the round dummy in each case. In almost all estimations, the coefficients of all round dummies are negative and statistically different from zero, except in round 4 of the probability of being moderately/severely food insecure. That means households' overall likelihood of becoming moderately/severely food insecure increases between round 3 and round 4 in Ethiopia, while it decreases in the other survey rounds. Thus, we can safely argue that households in Ethiopia have experienced a declining trend in food insecurity between round 2 (June 2020) and round 6 (late September 2020).

The impact of COVID-19 is likely to vary across households due to differences in underlying conditions of the households. Table 3 reports the results for the probability of households being moderately/severely food insecure (column 1-4) and the probability of households being severely food insecure (column 5-8) across various

heterogeneity variables. The interaction terms between dummy rounds and the heterogeneity variables capture the temporal variation in the evolution of food insecurity associated with households' location, sectors, ownership of land and livestock, and various income and livelihood sources.

The interaction terms between the survey rounds and rural (column 5) is statistically different from zero in the fifth round (i.e. 0.762 at 5%), indicating that households in urban areas faced a higher chance of being severely food insecure than those in rural households between round 4 and round 5 (July-August 2020). As the spread of the pandemic was initiated and spread in urban areas, government responses, including mobility restrictions and lockdowns, were mostly intensified in urban areas and are expected to affect urban residents more directly than rural households at least in the short term.

Again, the interaction terms between rounds and percentage of working adults working in the agricultural sector are negative and significant in round 3 and 4, (column 3) and round 5 (column 6), each at 10% level of significance. This implies that households with greater percentage of adult household members working in the agricultural sector have a lower probability of being food insecure (June/July/August 2020). This is expected since farming activities require relatively less human-to-human interaction and transportation technologies, they are supposed to be affected relatively less than the other livelihood activities.

Ownership of land has positive and significant coefficients in round 5 and 6 (column 2, Table 3) on the probability of being moderately/severely food insecure. Even though the coefficients are not statistically significant in most cases, ownership of land, in column 2 and column 6 of Table 3, present unexpected and mixed results on the differential impact of the pandemic on food insecurity. In fact, it is whether the land is cultivated or not, or being used for the intended purpose, that should determine the variation in food security, not just a simple ownership of the land. Whatsoever the case is, the implication of ownership of land by Ethiopian households could be a subject for discussion and further researches.

Moreover, livestock ownership is also a source of heterogeneity in the impacts of the COVID-19 pandemic in households' food security situation in Ethiopia. Column 4 and column 8 present results on the impact of COVID-19 on food insecurity by livestock ownership. The interaction terms in round 5 and 6 (column 8) are negative and statistically different from zero, which implies that households who own livestock have a decreased probability of being severely food insecure between the 4th and 5th round (July/August 2020) and between the between the 5th and 6th (August/September 2020).

TABLE 3. ESTIMATION RESULTS OF FE MODELS IN ETHIOPIA FOR LOCATION AND SECTORAL HETEROGENEITY

	Probability of being moderately/severely food insecure (P >= 50%)				Probability of being severely food insecure (P >= 50%)			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Round 3	-0.1959 (0.159)	-0.1125 (0.251)	-0.0276 (0.777)	-0.1031 (0.340)	-1.496* (0.000)	-1.121* (0.000)	-1.0810* (0.000)	-1.107* (0.000)
Round 4	0.307** (0.032)	0.3659* (0.000)	0.5022* (0.000)	0.409* (0.000)	-1.328* (0.000)	-1.563* (0.000)	-1.4806* (0.000)	-1.420* (0.000)
Round 5	-0.606* (0.000)	-0.664* (0.000)	-0.5178* (0.000)	-0.518* (0.000)	-1.432* (0.000)	-0.763* (0.000)	-0.7381* (0.001)	-0.462** (0.032)
Round 6	-0.8244 (0.000)	-0.840* (0.000)	-0.7091* (0.000)	-0.650* (0.000)	-1.220* (0.000)	-1.203* (0.000)	-1.1912* (0.000)	-0.806* (0.000)
Round 3*rural	0.1292 (0.451)				0.4293 (0.185)			
Round 4*rural	0.1624 (0.353)				-0.2371 (0.482)			
Round 5*rural	0.1075 (0.556)				0.762** (0.027)			
Round 6*rural	0.1171 (0.532)				0.074 (0.827)			
Round 3*land		0.0122 (0.947)				-0.3364 (0.318)		
Round 4*land		0.1795 (0.334)				0.2868 (0.407)		
Round 5*land		0.469** (0.015)				-0.5553 (0.115)		
Round 6*land		0.339*** (0.088)				0.0940 (0.785)		
Round 3*agri.			-0.004*** (0.091)				-0.005 (0.207)	
Round 4*agri.			-0.004*** (0.076)				0.0003 (0.938)	
Round 5*agri.			-0.0007 (0.749)				-0.007*** (0.096)	
Round 6*agri.			-0.0018 (0.470)				0.0007 (0.860)	
Round 3*livestock				-0.0220 (0.895)				-0.2604 (0.403)
Round 4*livestock				0.0144 (0.932)				-0.1250 (0.708)
Round 5*livestock				-0.0379 (0.829)				-1.015** (0.002)
Round 6*livestock				-0.2367 (0.192)				-0.780** (0.019)
Household FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Obs.	5,658	5,658	5,658	5,658	1,649	1,649	1,649	1,649

Note: *, ** and *** represent 1%, 5% and 10% levels of significance.

In the next section, the study explores potentially heterogeneous impacts of the pandemic across households with varying livelihoods activities and income sources. Our analysis in this regard is also in line with several studies across the world suggesting that the pandemic has had heterogeneous impacts on different livelihood options and sectors (Amare et al., 2020). The availability of baseline data allows estimating the impact of the pandemic across various socioeconomic groups and regions. In order to better understand the differential impacts, the study utilizes baseline characteristics of households to differentiate vulnerable households and income sources. So, the heterogonous impacts of the pandemic across households' income and livelihood sources such as rental income, remittance, assistance, and wage employment, among others are estimated and the results are presented in Table 4 below. These variables are interacted with round dummies to quantify the differential impact of the pandemic across the groups.

Column 1 and column 5 presents the interaction results between round dummies and rental income of households. Thus, coefficients in round 3 (0.583), round 4 (0.943), round 5 (0.894) and round 6 (1.166) are positive and statistically significant. This means that households whose income source was rental income previous to the onset of the pandemic have increased likelihood of being moderately/severely food insecure between round 2, round 3, round 4 and round 5 (between May and August 2020), and higher chance of being severely food insecure between round 5 and round 6 (August-September 2020). So, the impact of the pandemic is significantly heterogeneous among households with and without rental income. Businesses closure and decrease in economic activity due to the direct impacts of the pandemic and also government's containments measures could be attributed to this differential impact of the pandemic by rent income source.

Then, the interaction term between round and remittance is negative and significant only in round 5 (-0.427 at 10%) which indicates remittance had chance of decreasing probability of becoming food insecure in Ethiopia during the pandemic (column 2). Households who have been receiving assistance from the government before the onset of the pandemic have decreased chance of becoming moderately or severely food insecure in Ethiopia. The interaction between round dummies and assistance are negative and statistically significant different from zero in round 3 (-0.585), round 5 (-1.206) and round 6 (-0.736) at 1%, 5% and 10%, respectively, levels of significance. So, households relying on remittance and assistance income are not significantly harmed by the pandemic.

TABLE 4. ESTIMATION RESULTS OF FE MODELS IN ETHIOPIA FOR HETEROGENEITY BY HOUSEHOLDS' INCOME SOURCES

	Probability of being moderately/severely food insecure (P >= 50%)				Probability of being severely food insecure (P >= 50%)			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Round 3	-0.146*** (0.091)	-0.062 (0.505)	-0.070 (0.418)	-0.1126 (0.244)	-1.212* (0.000)	-1.167* (0.000)	-1.231* (0.000)	-1.2295* (0.000)
Round 4	0.359* (0.000)	0.385* (0.000)	0.429* (0.000)	0.3949* (0.000)	-1.467* (0.000)	-1.361* (0.000)	-1.536* (0.000)	-1.607* (0.000)
Round 5	-0.586* (0.000)	-0.454* (0.000)	-0.451* (0.000)	-0.5641* (0.000)	-0.965* (0.000)	-0.880* (0.000)	-0.897* (0.000)	-1.178* (0.000)
Round 6	-0.752* (0.000)	-0.707* (0.000)	-0.696* (0.000)	-0.8352* (0.000)	-1.237* (0.000)	-1.122* (0.000)	-1.203* (0.000)	-1.251* (0.000)
Round 3*rent	0.583*** (0.091)				-0.566 (0.531)			
Round 4*rent	0.943* (0.009)				-0.190 (0.838)			
Round 5*rent	0.894** (0.017)				0.851 (0.256)			
Round 6*rent	0.051 (0.897)				1.166*** (0.092)			
Round 3*remit		-0.253 (0.224)				-0.268 (0.489)		
Round 4*remit		0.171 (0.427)				-0.533 (0.214)		
Round 5*remit		-0.428*** (0.055)				-0.217 (0.578)		
Round 6*remit		-0.215 (0.349)				-0.245 (0.547)		
Round 3*assist			-0.585*** (0.056)				0.1562 (0.794)	
Round 4*assist			-0.253 (0.415)				0.8424 (0.147)	
Round 5*assist			-1.206* (0.001)				-0.486 (0.471)	
Round 6*assist			-0.736** (0.034)				0.4352 (0.482)	
Round 3*wage				0.0001 (0.990)				-0.002 (0.965)
Round 4*wage				0.0010 (0.695)				0.0102*** (0.088)
Round 5*wage				0.0015 (0.566)				0.0172* (0.002)
Round 6*wage				0.005*** (0.094)				0.0062 (0.384)
Household FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Obs.	5,658	5,658	5,658	5,658	1,649	1,649	1,649	1,649

Note: *, ** and *** represent 1%, 5% and 10% levels of significance.

Finally, column 4 and column 8 present the differential impact of the pandemic across wage activity as income source. And, the interaction coefficients are positive and significant in round 4 (0.010 at 10%) and round 5 (0.016 at 1%) which indicates that greater involvement in wage earning activities increases the chance of becoming moderately/severely food insecure between round 5 and 6, and severely food insecure between round 3 and 4 (June-July 2020), and between round 4 and 5 (July-August 2020). This is expected since wage-related activities could be closed or, stooped working or fired their workers due to the government's containments measures and the pandemic's direct economic impact.

TABLE 5. TEST OF JOINT SIGNIFICANCE OF INTERACTION TERMS (HETEROGENEITY INDICATOR VARIABLES)

No.	Interactions terms (heterogeneity indicators)	Probability of being moderately/ severely food insecure >= 50%		Probability of being severely food insecure >= 50%	
		Chi2(4)	Prob>chi2	Chi2(4)	Prob>chi2
1	Round*rural	1.00	0.9102	8.92	0.0630
2	Round*land	8.72	0.0684	6.13	0.1896
3	Round*agri.	4.87	0.3013	4.98	0.2894
4	Round*livestock	2.36	0.6705	13.19	0.0104
5	Round*rent	10.71	0.0300	5.16	0.2711
6	Round*remit	8.30	0.0811	1.61	0.8078
7	Round*assist	13.47	0.0092	4.14	0.3877
8	Round*wage	3.59	0.4642	11.70	0.0197

Joint significance of the interactions between each heterogeneity indicator variable and the round dummy are tested and presented in Table 5. The impact of COVID-19 on moderate/severe food insecurity is heterogeneous between those households who own land, earn rental income, and receive remittance and assistance and those households who do not.

Besides, there is statistically significant difference in the impacts of the pandemic on severe food insecurity between urban and rural households. It brings also heterogeneous severe food insecurity between those who owns livestock and those who do not. Households who rely on wage employment are exposed to a significant differential impact of the pandemic than those who do not. Overall, rural/urban, ownership of land and livestock, rental income, remittance, assistance and wage employment are statistically significant heterogeneous indicator variables on the impacts of the early days of COVID-19 on households overall food security.

As a robustness check, we estimate the models above using subsamples and different specifications (estimation results are available in the log-file attached as appendix). First, we estimate the fixed effect model specifications using only the subsample of households that do not live in Addis Ababa. This is to test the possibility that our findings are driven by households in Addis Ababa, by far the largest city in Ethiopia and unique in many aspects. Secondly, the fixed effect models are re-estimated by excluding the additional time-variant controls for household characteristics, such as

change in household head, household size, adult equivalence, and number of household members whose is below 15 years and above 65 years. The results confirmed that our findings are robust against the change in the subsample and model specifications used in the estimation. Excluding Addis Ababa from the sample and omitting the time variant household characteristics from the specification and estimation of the fixed effect model does not substantially change the results. In all cases, the findings remain the same. So, the fixed models specified and estimated are appropriate.

CONCLUSIONS

COVID-19 affects food security of households through different pathways. COVID-19 related lockdowns and social distancing measures can adversely affect incomes by reducing economic and livelihood activities, which directly affects food security of households. Several studies from different developing countries, including Africa, show that the pandemic has had heterogeneous impacts on food security, various livelihood options and sectors in their economy. This study intended to explore the trajectory and heterogeneous impacts of the early days of the COVID-19 pandemic on food insecurity across households with different location or sectors, ownership of assets and varying livelihoods and sources of incomes in Ethiopia. It has used a nationally representative harmonized panel data on households drawn from the high frequency phone survey and national longitudinal Ethiopia Socioeconomic Survey (ESS) that the Central Statistical Agency (CSA) carried out in collaboration with the World Bank.

The fixed-effects regression results show that the COVID-19 pandemic had a statistically significant impact on overall food insecurity in Ethiopia. Households have experienced a declining trend in food insecurity between round 2 (June 2020) and round 6 (late September 2020). The joint significance test shows that rural/urban, ownership of land and livestock, rental income, remittance, assistance and wage employment are statistically significant heterogeneous indicator variables on the impacts of the early days of COVID-19 on households' overall food insecurity.

Specifically, households in urban areas faced a higher chance of being severely food insecure than those in rural households between July-August 2020. It also shows that households that rely more on the agricultural sector have a lower odds of being food insecure (June - August 2020) than those households who do not. Moreover, livestock ownership is also a source of heterogeneity in the impacts of the COVID-19 pandemic in households' food security situation in Ethiopia. Households who own livestock have a decreased probability of being severely food insecure between the 4th and 5th round (July-August 2020) and between the between the 5th and 6th (August-September 2020).

Besides, households whose income source was rental income previous to the onset of the pandemic have increased likelihood of being moderately/severely food insecure between round 2, round 3, round 4 and round 5 (between May and August 2020), and higher chance of being severely food insecure between round 5 and round 6 (August-September 2020). So, the impact of the pandemic is significantly heterogeneous among households with and without rental income.

The interaction term between round dummies and remittance is negative and statistically significant only in round 5, and between round dummies and assistance are negative and statistically significant different from zero in round 3, round 5 and round 6. This suggests the significant role that has been played by remittance and assistance income in protecting households from deteriorating trajectory of food insecurity during the pandemic in the short term.

Finally, the coefficients relating round dummies and wage employment are positive and statistically significant in round 4 and round 5, and this suggest that indicates that greater involvement in wage earning activities increases the chance of becoming moderately/severely food insecure between round 5 and 6, and severely food insecure between round 3 and 4 (June - July 2020), and between round 4 and 5 (July - August 2020). Households that have been relying on wage employment as income source were significantly exposed to food insecurity due to the pandemic.

The findings of the study can be used to informing short term and medium-term policy responses and interventions by the government at different levels and international donor organizations. It could inform safety nets and social protection policy interventions aiming at ameliorating the impacts of the pandemic, as well as pinpoint tailored strategies by identifying the most impacted households or members of the populations. In the short term, it was important to provide direct support to those households in the form of, for example, cash transfers and food rationing. In the medium term, it might have been useful to build disadvantaged groups and households' resilience against shocks by improving their accessibility to jobs, and markets for food and make transactions. This informs that the country should strengthen its programs and woks on social protection and rehabilitation through safety net programs so that it could have supported the severely exposed households. This is an important lesson that the same preparation is required for future unforeseen economic shocks.

Finally, the scope of the analysis does not allow distinguishing specific pathways in the COVID-19 impacts on urban households' only or rural households only. For instance, in large and densely populated towns, people are less likely to travel during the pandemic in view of the high contagion risk and relatively strict mobility restrictions and lockdowns. This could be a source of heterogeneity in COVID-19 impacts among urban households only. Also, it does not look at other potential paths of differential impacts of the pandemic. For example, the disadvantaged groups of

workers who live far from their workplace are supposed to be hit hard by mobility restrictions. Those household members with no option to work remotely and need to travel around for their jobs in self-employment may have been particularly vulnerable to mobility shocks and exposed to food insecurity problem.

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