Gender and Spatial Heterogeneity in the Impacts of Covid-19 on Households' Income in Ethiopia: Evidence from High Frequency Phone Survey

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Abstract

This paper examines the existence or otherwise of gender and spatial heterogeneity in the impacts of the early days of the Covid-19 pandemic on households' total incomes in Ethiopia. Using the first round of the World Bank's high frequency phone survey on 3224 households, the logit model regression analysis finds that households in different regions of the country are affected disproportionately and heterogeneously. In order to examine the existence of heterogeneity, a logit model containing interaction terms between gender, and region dummies six Covid-19 containment measures have been fitted on binary outcome of change in total income of households. Linktest of specification, Hosmer-Lemeshow goodness-of-fit test, VIF and tolerance index of multicollinearity tests and various influential observations tests are conducted in order to fit models that can handle the heterogeneity analysis of the impacts of the pandemic on households' total income in Ethiopia. The results suggest the existence of statistically significant regional heterogeneity in the impacts of within country travel restriction, limit on social gatherings and closure of schools and universities on the total income of households. Restriction on international travel, curfew/lockdown and closure of non-essential businesses do not bring heterogeneous impacts across gender and region of households. Gender of the household head is insignificant determinant of change in households' income and also does not cause heterogeneous impacts. Overall, in Ethiopia there exists region-based heterogeneity in the impacts of Covid-19 on households' total income. The results imply the relevance of income policy measures that can lessen shocks to household's income, and livelihood after a pandemic such as Covid-19.

Keywords: Covid-19; Impacts; Household Income; Heterogeneity; Ethiopia.

1. Introduction

Covid-19 pandemic represents an unprecedented social and economic disruption in the modern history of 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).

Ethiopia's first Covid-19 case was observed in mid-March 2020. 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, Ethiopia 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 (ibid).

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 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).

The asymmetry in the economic impacts of the pandemic and respective policy interventions along several dimensions is one of its salient features. The actions taken by agents and policymakers have resulted in very different economic effects across sectors and regions (Cerezo et al 202). Studies have revealed that the impacts of the Covid-19 pandemic on household incomes and welfare have been spatially uneven. 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).

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 in 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. Self-employed households experienced severer income loss in earlier rounds. Also, poor 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 (Batana et al 2021).

Besides, there is limited number of studies conducted in Ethiopia on the impacts of the pandemic. Even those available, are focused on analyzing its macroeconomic effects, and a few on livelihood and food security impacts. Also, less is known about the asymmetric effects of the pandemic on Ethiopian households' total income. Therefore, the purpose of this paper is to shed light on this issue using a household level survey data. In particular, the paper is intended to examine the heterogeneity in impacts of Covid-19 on households' total income across gender and regions in Ethiopia. It also examines which of the Covid-19 containment measures are significant in impacting households' income in Ethiopia.

The remaining part of the paper is organized as follows. Part two presents a literature review, followed by data and methods in part three. Results and discussions are made in part four and finally part five contains conclusions and implications.

2. Literature Review

Since the onset of the Covid19, many studies have been conducted and published on the multi-dimensional impact of the pandemic. For the purpose of substantiating the rational of this study and informing its methodology development, review of a few empirical literatures on the impacts of the pandemic at global, 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 fits logistic regressions of four main indicators on a set of explanatory variables and country or region dummies. The dependent variable includes stop working, income loss, food insecurity, or continued learning. The findings show that 36% of respondents stopped working in the immediate aftermath of the pandemic, over 64% of households reported decreases in income. 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. The unequal impacts of the pandemic across socioeconomic groups risk cementing inequality of opportunity and undermining social mobility and call for policies to foster an inclusive recovery and strengthen resilience to future shocks.

Liu et al. (2020) investigated the impact of Covid-19 on Chinese household consumption. Using China's household finance survey data, the study applied OLS method to analyze the impact of the pandemic on household consumption. To capture the impact's 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. Moreover, mobile payment promotes urban household consumption during the pandemic, while rural households remain unaffected.

Using a computable general equilibrium model-based simulation, Kabir et al. (2021) assessed the gender dimensions of the impact of Covid-19 on economic outcomes, that is, labor force participation, employment, wages, and earnings. Using the probit model and the 2020 High-Frequency Phone Survey in Chad, it has examined the impact of Covid-19 on female-headed households. The main binary outcome is the reduction in household income from various sources in the past 12 months, constructed from any source and for each income source: wage employment, non-farm enterprise income, farm income, remittance. The findings show 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 study showed that Covid-19 has notably impacted the households' income from enterprises and suggests that this negative impact is more prevalent for female-headed households.

Consolazio et al. (2021) assessed the role of five area level indicators in shaping the risk of contagion in Italy, namely: unemployment, educational disadvantage, housing crowding, mobility, and population density. It has applied multilevel logistic regression model 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 across province of residence and before and after the lockdown measures. 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). Since the two countries have been affected by Covid-19 in varying degrees, and the containment measures put in place varied, with anticipated differences in effects on food and nutritional outcomes. Using responses from 313 and 129 people in Kenya and Uganda respectively, it has fitted a probit model so as 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 two-thirds of the respondents experienced income shocks due to the Covid-19 crisis. Food security and dietary quality worsened, as measured by the food insecurity experience scale and the frequency of consumption of nutritionally-rich foods. Results from probit regressions show that the income-poor households and those dependent on labour income were more vulnerable to income shock, and had poorer

food consumption during the pandemic compared to other respondent categories. Farmers were less likely to experience worsened food security compared to other respondent categories who depended to a great extent on market sources for food. Conversely, membership in savings and loan groups was correlated with less likelihood of suffering income shocks and reduction in food consumption (Kansiime et al. 2021).

A study by Bukari et al. (2021) examined the differential effects of Covid-19 on poverty and living standards of households in Ghana. It has fitted ordinary least squares, probit model and simultaneous quantile regressions on a data gathered from 3,905 households. Results showed that Covid-19 had significantly increased the poverty levels of households while deteriorating living standards. The study also discovered that gender and locational heterogeneities exist in the impacts of Covid-19 with females and rural dwellers mostly disadvantaged. However, simultaneous quantile regression result shows that in terms of overall household consumption, those in the middle and upper classes are profoundly affected.

In Ethiopia, Beyene et al. (2020) examined the potential economy-wide impacts of the Covid-19 in Ethiopia. The paper has employed a dynamic computable general equilibrium model calibrated to a social accounting matrix for FY 2010/11 and covers the period from FY 2010/11 to FY 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. The impact of the Covid-19 crisis is analyzed using three scenarios, namely business as usual, and the Covid-19 scenario considered under mild and severe assumptions. The results showed that the pandemic is 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).

Moreover, 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 the two countries points to the spatial heterogeneity of COVID-19 impacts, implying the critical role of mobility and accessibility in urban agglomerations (Batana et al. 2021).

A zonal study in Ethiopia 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. Data from 275 respondents were collected through interview schedules, key informants and case studies from September to November 2020. Descriptive statistics, binary logistic regression model and qualitative approaches were employed to analyze the data. The results showed that the lives and livelihoods impacts varied depending geo-local settings and pre-pandemic livelihood activities of the target districts. The has finally 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 (Asegie et al. 2021).

3. Data and Methods

3.1. Data type and variables

The empirical analysis relies on a 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. The

questionnaire covers topics such as knowledge of Covid-19 and mitigation measures, access to educational activities during school closures, employment dynamics, household income and livelihood, income loss and coping strategies, and assistance received (Batana et al. 2021).

This study uses a cross-section data of the first round of the survey conducted between April and May, 2020 so as to examine the impact of covid-19 pandemic on total income of households. The total income includes farm and nonfarm incomes, wage incomes, remittances, pension, government assistance and others). Using the households' id as the main identifier and following the required data management processes, a cross-section data on a total of 3,224 households was extracted from the microdata accessed from the World Bank's website.

Dependent variable: Change in total income of households after the outbreak of the pandemic in Ethiopia is the dependent variable used in this research. It takes binary values, where "increase or remaining the same" takes "0" and "decrease or 100 percent loss" in total income takes the value of "1".

Explanatory variables and predictors: The independent variables for the study comprised individual and household characteristics. They included gender, age and education level of the household head, household size, region of the household location, various containment measures taken by the government. Among them, the following six measures are selected to be used as predictor variables of the analysis: restricted travel within country; restricted international travel; limiting social gatherings; curfew or lockdown; closure of non-essential businesses; and closure of schools and universities. Finally, in order to check for the existence of gender and spatial heterogeneity on the impact of the pandemic, interaction terms between the indicator and predictor variables are generated and included in the analysis. The indicator variables are gender and region, while the predictors are the six containment measures mentioned here above, which are used as proxy variables to represent covid-19 in the model.

3.2. Analytical method

The results from the HFPS indicate severe employment and income impacts in Ethiopia (Bundervoet et al. 2021). Also, based on the empirical review results, it is hypothesized that income impacts of the Covid-19 containment measures are expected to be spatially and sexually heterogeneous in Ethiopia.

3.2.1. Logit model of heterogeneity analysis

In a nonlinear model, the dependent variable is a nonlinear function of the index of independent variables. The dependent variable of interest is the probability that y =1 (Norton et al. 2004). In order to capture heterogeneity among groups of the sample population, the model is formulated in a way that the dummy dependent variable depends on independent variables, their interaction, and a vector of additional independent variables, including the constant term.

This study used a logit model where a continuous latent variable is behind the binary response variable of the model. In order to compare coefficients obtained from logit models that hold in subpopulations or groups, there is no need to fit logit models separately in groups. The model can be fitted and estimated for both groups simultaneously by including an indicator variable for the group. This has conceptual advantages and directly provides tests that compare coefficients within the framework of generalized linear models (Tutz, 2019).

Assume Y_i^* *is* a continuous variable whose response outcomes are grouped in too two. Therefore, the latent regression model have the form

$$Y_i^* = \alpha_0 + x_{i1}\alpha_1 + \cdots + x_{ip}\alpha_p + \sigma\varepsilon_i,$$

where ε_i has symmetric distribution function. Y_i is dichotomized version of the latent variable, income, and $Y_i = 1\ if\ Y_i^* \geq \theta$, where $\theta\ is\ some\ unlnown\ threshold$. In this research, the dependent variable is income change with two outcomes, a decrease or 100% loss in households' total income after outbreak of the pandemic.

If the probability of $Y_i = 1,\ \pi_i = P(Y_i = 1|x_i)$. Then, the logit model is given by

$$\text{logit}\,(\pi_i) = \beta_0 + x_{i1}\beta_1 + \cdots + x_{ip}\beta_p$$

The heterogenity analysis is condcuted by fitting a logit model for both groups simultaneously. That is, in the total population by including an indicator variable representing the group.

Let the indicator variable be $x_{i0} = 1$ in group 1 and $x_{i0} = 0$ in group 0. The model for the total population that corresponds to the models for each group is the logit model with specific interactions

$$logit\ (\pi_i) = \beta_{00} + x_{i0}\beta_0 + x_{i1}\beta_1 + \cdots + x_{ip}\beta_p + x_{i0}x_{i1}\beta_{01} + x_{i0}x_{ip}\beta_{0p}$$

The model contains main effects of the indicator variable and the explanatory variables and all the interactions between the group indicator and the explanatory variables.

Above all, the theory is used to guide building of a model that can handle the heterogeneity in the impacts of the pandemic on households' total income. Then, it has checked the models for specification issues, goodness-of-fit, multicollinearity and influential observations.

Model specification is tested using the linktest, while goodness-of-fit test is made using the Pearson or Hosmer-Lemeshow method. Multicollinearity is tested through the variance inflation factor and tolerance index. Likelihood ratio test is employed to choose the better preforming model. Influential observations are examined through plots of the statistics against the predicted values and index id. Additionally, the study has used Pregibon delta beta influence statistic to test the influence of each individual observation on the coefficient estimate, Hosmer and Lemeshow on chi-square influence, and deviance statistic.

4. Results and Discussions

4.1. Model diagnostics

Since it has fitted various models for each Covid-19 containment measures taken by the government, the diagnostic tests are also made for each logit model estimated.

4.1.1. Specification and goodness-of-fit tests

The logit model is chosen because the misspecifications of the link function is usually not too severe compared with using other alternative link function choices. In practice, attention was given whether the model has all the relevant predictors and if the linear combination of them is sufficient.

Restriction on within country travel/movement: For the restriction on within the country travel or movement, all the variables except, gender and in_travel dummies, are significant, including the categorical variables (education, with Prob > chi2 = 0.0122 and region with Prob > chi2 = 0.0000), which are jointly significant in determining the probability of income decrease due to within country travel restriction. The linktest that followed the variable _hatsq is insignificant, with p-value = 0.889. In the second model, which includes interaction terms between gender and region dummies, and dummy of restriction on within country travel/movement, coefficients of the interaction terms are jointly statistically significant with Prob > chi2 = 0.0069, expect for gender. The linktest result of _hatsq is also insignificant with P>|z| = 0.859 (Table 1). Thus, the statistically insignificant linktest suggest that both models have no specification errors.

Table 1: Specification test for models fitted for each Covid-19 containment measure

Model of each Covid-19 containment measure	_hatsq linktest statistics			
	main effect model		main & interaction effect model	
	z	P>|z|	z	P>|z|
Restriction on travel within the country	-0.14	0.889	-0.18	0.859
Restriction on international travel	-0.16	0.876	-0.12	0.903
Limitation on social gatherings	-0.14	0.889	-0.24	0.811
Curfew/lockdown	0.16	0.874	0.42	0.676
Closure of non-essential businesses	0.33	0.741	-0.74	0.459
Closure of schools and universities	0.46	0.646	-0.18	0.858

(Source: own computation using STATA)

Restriction on international travel: In the main effect model, all the variables are jointly statistically significant with Prob > chi2 = 0.0000. The _hatsq of linktest is insignificant (with p-value = 0.876), and suggest the absence of specification error in the main effect model. Besides, the model with main effect and interaction effect is also significant since the entire variables are jointly significant with Prob > chi2 = 0.0000. Each categorical variable is also significant, education with Prob > chi2 = 0.0136 and region with Prob > chi2 = 0.0000. The interaction terms of restriction on international travel dummy with gender (P>|z| = 0.359) and region (Prob > chi2 = 0.1245) identifiers are jointly insignificant. Most importantly, the linktest result of _hatsq is insignificant with P>|z| = 0.903, which implies absence of specification error in the heterogeneity model that includes interaction terms.

Limit on social gatherings: Likewise, in both models (main effect model and model with main effect and interaction effect) of government's limit on social gatherings, all the variables included are all jointly statistically significant with Prob > chi2 = 0.0000. The categorical variables are also significant. The linktest suggest that both models have no specification error, main effect model with p-value = 0.889 and main effect and interaction effect with a p-value = 0.811.

Curfew or lockdown measure: The main effect model of the government's curfew or lockdown measure, all the variables included are all jointly statistically significant with Prob > chi2 = 0.0000. The categorical variables are also significant, Also, the _hatsq of linktest is insignificant (with p-value = 0.874) which justifies absence of specification problem. In the second model, with interaction terms, even if it looks to have overall significance and no specification issue from the linktest result, the region-curfew interaction terms are jointly and individually statistically insignificant.

Closure of non-essential businesses: Both models have overall statistical significance. Also, the region categorical viable including its interaction with dummy of closure of non-essential businesses are jointly statistically significant. Likewise, in the main effect model of the government's closure of non-essential businesses, all the variables included are all jointly statistically significant with Prob > chi2 = 0.0000. The categorical variables are also significant, education with Prob > chi2 = 0.0140 and region with Prob > chi2 = 0.0000. The linktest of _hatsq is insignificant (with p-value = 0.741) in the main model which suggests that our model is well-specified. In the model that includes heterogeneity variables, interaction terms of government's curfew dummy with gender and few of region dummies are each insignificant. The region-based interaction terms are also jointly insignificant with Prob > chi2 = 0.3951. The linktest, however, indicates absence of specification error.

Closure of schools and universities: Here also, both models fitted for the government's closure of schools and universities have an overall and jointly statistically significant variables with Prob > chi2 = 0.0000. Both categorical variables are also significant in both models. The linktest in both models also gives insignificant test results which implies that our specification in the models have no problem so that we can proceed them.

Hosmer and Lemeshow's goodness-of-fit test statistics (Table 2) shows that both the main effect model and the model which adds interaction effect have large probabilities of chi-square (Prob > chi2) for all specifications. And, this suggests that all the six models fit the data well. This, therefore, indicates on one hand that we have to use model selection tests.

Table 2: Hosmer-Lemeshow goodness-of-fit test for each model

Model of each Covid-19 containment measure	Hosmer-Lemeshow test statistics	
	main effect model	main & interaction effect model
	Prob > chi2	Prob > chi2
Restriction on travel within the country	0.7337	0.1275
Restriction on international travel	0.8694	0.6907
Limitation on social gatherings	0.7337	0.9854
Curfew/lockdown	0.9854	0.6959
Closure of non-essential businesses	0.6076	0.7640
Closure of schools and universities	0.5052	0.8265

4.1.2. Multicollinearity and influential observations test

Collinearity diagnostics are used to examine the existence or otherwise of multicollinearity among model variables. At the beginning of variable identification and definition, collinearity is checked using correlation or covariance matrix. Thus, age and household size variables are centered at their mean. Then, after the models are fitted, the VIF and Tolerance indexes are checked for each model.

The multicollinearity diagnostic of the final specification of the main effect model has a maximum VIF of 1.16, mean VIF of 1.09 and a minimum tolerance of 0.806; while the model which includes interaction terms has a maximum VIF of 2.57, mean VIF 1.49 and minimum tolerance index 0.3889. Most of the variables, however, have very large tolerance index, and this implies that multicollinearity is not a problem in both models specified. Likewise, there is not multicollinearity problem in the logit models fitted for restriction on international travel, where the maximum VIF is 3.27 in both models and the minimum tolerance is 0.3062 (Table 3).

Table 3: Collinearity diagnostics test statistics for each model

Model of each Covid-19 containment measure	Collinearity Diagnostics					
	main effect model			main & interaction effect model		
	Mean VIF	Max VIF	Min tolerance	Mean VIF	Max VIF	Min tolerance
Restriction on travel within the country	1.09	1.16	0.8606	1.49	2.57	0.3889
Restriction on international travel	1.53	2.71	0.3692	1.60	3.27	0.3062
Limitation on social gatherings	1.52	2.37	0.4227	4.07	8.40	0.1190
Curfew/lockdown	1.48	2.17	0.4603	1.83	3.60	0.2776
Closure of non-essential businesses	1.45	2.18	0.4587	1.84	3.33	0.3006
Closure of schools and universities	1.43	2.05	0.4880	2.59	8.58	0.1166

Additionally, limit on social gathering's main effect model has a maximum VIF of 2.37 and a minimum tolerance index of 0.4227. Most of the variables, however, have very small VIF and very large tolerance index. The main and interaction effects model has a maximum VIF 8.40, mean VIF 4.07 and tolerance indexes greater than or equal to 0.1190. This shows the existence of some level of collinearity among the variables, bust still it is tolerable. In a similar way, all the models estimated for the remaining containment measures have very small VIF and large tolerance indexes in all cases, which suggest that multicollinearity is not a problem in these models so that we can proceed to comparison of models performance and select the better one.

In order to check for existence of *influential observations* that could impact the estimation results, plots of the statistics against the predicted values, and also against the index id (also called an index plot) are fitted after each model's estimation. The plots show that there are no observations that are very far away from most of the other observations. Additionally, we have conducted additional diagnostics to identify observations with substantial impact on either the chi-square fit statistic or the deviance statistic. A diagnostic statistics, called DFBETA influence statistics, is made to examine coefficient's sensitivity, which tests the influence of each individual observation on the coefficient estimate. And, the results suggest that the models fitted using the existing data is free from problems that could be posed by existence influential observations.

4.2. Heterogeneity in the impacts Covid-19 on households' income

Within country travel restriction: Since our main objective is to examine the existence of gender and spatial (region-based) heterogeneity, we focus on the model estimated with interaction terms between gender and region and within country travel restriction dummy. In fact, the likelihood-ratio test implies that model 2 (fitted with interaction) is better than model 1 (main effect model with no interaction effect) with Prob > chi2 = 0.0059.

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Likelihood-ratio test                                 LR chi2(11) =     26.29
(Assumption: model 1 nested in model 2)               Prob > chi2 =    0.0059
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In the estimation, the first region, i.e. the Tigray regional state, is used as a base category in all estimation following. The region-based interaction terms are jointly significant at Prob > chi2 = 0.0069; while with gender, it is insignificant. This implies the existence of regional heterogeneity in the impacts of within country travel restriction on households' total income. Households' from SNNPR, Gambela, Addis Ababa and Dire Dawa have faced higher chance of income reduction or loss as compared to those in Tigray region (Table 4). The reductions in income are, however, disproportionate.

Table 4: Estimation results of logistic regression: within country travel restriction

Change in income of households	*Coef.*	*Std. Err.*	*z*	*P>z*
*Gender*within country travel restriction*	*0.2532022*	*0.2110679*	*1.20*	*0.230*
Afar within country travel restriction*	*-0.0768253*	*0.4928605*	*-0.16*	*0.876*
*Amhara*within country travel restriction*	*-0.5705538*	*0.3603747*	*-1.58*	*0.113*
*Oromia*within country travel restriction*	*-0.6471984*	*0.4225902*	*-1.53*	*0.126*
*Somali*within country travel restriction*	*-0.2785578*	*0.8466865*	*-0.33*	*0.742*
*Ben. Gumuz*within country travel restriction*	*-0.2939146*	*0.5031191*	*-0.58*	*0.559*
*SNNPR*within country travel restriction*	*-0.9998278*	*0.5398588*	*-1.85*	*0.064***
*Gambela*within country travel restriction*	*0.3210362*	*0.4962255*	*0.65*	*0.518***
*Harar*within country travel restriction*	*-0.0786255*	*0.3918808*	*-0.20*	*0.841*
*Addis Ababa*within country travel restriction*	*-1.177335*	*0.5511019*	*-2.14*	*0.033**
*Dire Dawa*within country travel restriction*	*-1.635957*	*0.4441366*	*-3.68*	*0.000**
_constant	*-0.1531189*	*0.2370109*	*-0.65*	*0.518*

(, ** and *** refer to 1%, 5% and 10% levels of significance, respectively)*

International travel restriction: The likelihood-ratio (LR) test statistic shows that model 4, the heterogeneity model, is better than mode 3, homogeneity model, with a Prob > chi2 = 0.0379.

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Likelihood-ratio test                                 LR chi2(9)  =     17.77
(Assumption: model 3 nested in model 4)               Prob > chi2 =    0.0379
```

Even if the model with interaction variables is preferred to the main effect model based on the likelihood test result, both gender and regional based interaction terms with international travel restriction dummy are insignificant. This suggests the absence of gender and regional heterogeneity in the impacts of international travel restriction on Ethiopian households' total income due to covid-19 outbreak. It has, however, significant impact on households'' income in Amhara regional state and Addis Ababa and Dire Dawa city administrations (Table 5).

Table 5: Estimation results of logistic regression: international travel restriction

Decrease in households total income	Coef.	Std. Err.	z	P>z
Gender*int'l travel restriction	0.352414	0.383953	0.92	0.359
Amhara*int'l travel restriction	-1.685524	0.770851	-2.19	0.029**
Oromia*int'l travel restriction	-0.061140	0.740066	-0.08	0.934
Ben. Gumuz*int'l travel restriction	-0.622343	0.952731	-0.65	0.514
SNNPR*int'l travel restriction	-0.558202	1.009207	-0.55	0.580
Gambela*int'l travel restriction	-0.288683	0.632734	-0.46	0.648
Harar*int'l travel restriction	-0.726743	0.589105	-1.23	0.217
Addis Ababa*int'l travel restriction	-1.775153	0.839653	-2.11	0.035**
Dire Dawa*int'l travel restriction	-2.680309	1.233064	-2.17	0.030**
Constant	-.3328143	0.172277	-1.93	0.053

(, ** and *** refer to 1%, 5% and 10% levels of significance, respectively)*

Limit on social gatherings: The likelihood-ratio test implies that the heterogeneous model (model 6) is better than the homogenous model (model 5) with a Prob > chi2 = 0.0208. That means, the model specified to capture heterogeneity is preferred, this confirms the existence of locational heterogeneity in the impacts of the pandemic through the government's limit on social gatherings.

```
Likelihood-ratio test                                 LR chi2(11) =     22.49
(Assumption: model_5 nested in model_6)               Prob > chi2 =    0.0208
```

Table 6 presents the estimated coefficients and probabilities of the heterogeneity model of impact of the restriction on social gatherings**.** When compared with Tigray region, the base category, households from Afar, Amhara, Oromia, Harar and Addis Ababa are more likely to face income reduction because of government's limit on social gatherings. Overall, limit on social gathering is statistically significant in bringing heterogeneous impact on the total income of households in Ethiopia.

Table 6: Estimation results of logistic regression: limit on social gatherings

Decrease in households total income	Coef.	Std. Err.	Z	P>z
Gender*social limit	.0468856	.1966747	0.24	0.812
Afar*social limit	-.986884	.4132277	-2.39	0.017**
Amhara*social limit	-.6745435	.3834434	-1.76	0.079***
Oromia*social limit	-.6772498	.3766057	-1.80	0.072***
Somali*social limit	.3043886	.6187935	0.49	0.623
Ben. Gumuz*social limit	-.6529306	.4819243	-1.35	0.175
SNNPR*social limit	-.2521624	.4843127	-0.52	0.603
Gambela*social limit	-.6755674	.4521747	-1.49	0.135
Harar*social limit	-.8859034	.4636693	-1.91	0.056***
Addis Ababa*social limit	-1.287102	.3442953	-3.74	0.000*
Dire Dawa*social limit	-.1960028	.3988495	-0.49	0.623
_cons	-.2785733	.2459108	-1.13	0.257

(, ** and *** refer to 1%, 5% and 10% levels of significance, respectively)*

Curfew or lockdown: The likelihood-ratio test implies that main effect model is better than the model that includes interaction terms, with a Prob > chi2 = 0.4452. That means, the model specified to capture impact heterogeneity with interaction terms is not preferred.

```
Likelihood-ratio test                                 LR chi2(11) =     10.98
(Assumption: model_7 nested in model_8)               Prob > chi2 =    0.4452
```

Besides, the interaction terms of curfew with region dummies are jointly insignificant with Prob > chi2 = 0.6410. Gender is also insignificant factor. Therefore, there is not gender and region-based heterogeneity in the impacts of curfew or lockdown on households' total income. The main effect mode shows, however, that curfew or lockdown is a significant measure that affects the change in households' total income with Prob > chi2 = 0.0000 (Annex).

Closure of non-essential businesses: Regarding the closure of non-essential businesses, the likelihood-ratio test implies that the model that includes interaction terms is better, with a Prob > chi2 = 0.0359.

```
Likelihood-ratio test                                 LR chi2(10) =     19.36
(Assumption: model_9 nested in model_10)              Prob > chi2 =    0.0359
```

However, the interaction terms between closure of non-essential businesses and region dummies are jointly and as well as individually are insignificant. This tells us that households' region of

location in the country does not bring heterogeneity in the impacts of closure of business on their total income due to the pandemic (Table 7).

Table 7: Estimation results of logistic regression: closure of non-essential businesses

Decrease in households' income	Coef.	Std. Err.	**z**	**P>**z
Gender*Business Closure	0.3641977	0.2548506	1.43	0.153
Afar*Business Closure	-0.382916	0.4562373	-0.84	0.401
Amhara*Business Closure	-0.5484305	0.3835379	-1.43	0.153
Oromia*Business Closure	0.1184344	0.5053328	0.23	0.815
Beshangul Gumuz*business closure	-0.8431315	0.6805885	-1.24	0.215
SNNPR*Business Closure	-1.582819	0.9665036	-1.64	0.101
Gambela*Business Closure	-0.6467627	0.5418351	-1.19	0.233
Harar*Business Closure	-0.1829274	0.3951824	-0.46	0.643
Addis Ababa*Business Closure	-1.02623	0.4843314	-2.12	0.034
Dire Dawa*Business Closure	0.0015865	0.9163304	0.00	0.999
Constant	-0.1272684	0.1763372	-0.72	0.470

(, ** and *** refer to 1%, 5% and 10% levels of significance, respectively)*

Closure of schools and universities: The likelihood-ratio test rejects the restrictions imposed by the main effect model. This implies that the model that includes interaction terms is preferred (Prob > chi2 = 0.0097). This, therefore, asserts that a statistically significant region-based heterogeneity exists in the impacts of closure of schools and universities on the households' total income due to the outbreak of the covid19 pandemic in the country.

```
Likelihood-ratio test                                 LR chi2(11) =     24.82
(Assumption: model_11 nested in model_12)             Prob > chi2 =    0.0097
```

The joint significance test on the moderation terms between region dummies and closure of schools and universities dummy are significant with Prob > chi2 = 0.0067. Therefore, we can say that location heterogeneity exists in the impacts of closure of schools and universities on the change in households' total income at the onset of the outbreak. There is no still gender-based heterogeneity in the impacts. When compared with the base category (i.e. Tigray regional state), households from all regions, except Somali, SNNPR and Dire Dawa town administration suffered statistically significant reduction in their total income from the closure of schools and universities (Table 8).

Table 8: Estimation results of logistic regression: **closure of schools and universities**

Decrease in households total income	*Coef.*	*Std. Err.*	*z*	*P>z*
*Gender*school closure*	*-.0475776*	*.1959484*	*-0.24*	*0.808*
*Afar*school closure*	*-1.266416*	*.4256279*	*-2.98*	*0.003**
*Amhara*school closure*	*-1.046558*	*.3649847*	*-2.87*	*0.004**
*Oromia*school closure*	*-1.31855*	*.354192*	*-3.72*	*0.000**
*Somali*school closure*	*.2260654*	*.5910333*	*0.38*	*0.702*
*Benshangul Gumuz*school closure*	*-1.247307*	*.4095166*	*-3.05*	*0.002**
*SNNPR*school closure*	*-.3213505*	*.5618898*	*-0.57*	*0.567*
*Gambela*school closure*	*-.875359*	*.4834229*	*-1.81*	*0.070****
*Harar*school closure*	*-.9148823*	*.3953439*	*-2.31*	*0.021***
*Addis Ababa*school closure*	*-1.121918*	*.4085598*	*-2.75*	*0.006**
*Dire Dawa*school closure*	*-.3734759*	*.731136*	*-0.51*	*0.609*
_cons	*-.2885259*	*.1701558*	*-1.70*	*0.090*

(, ** and *** refer to 1%, 5% and 10% levels of significance, respectively)*

5. Conclusions and Implications

Covid-19 pandemic has brought an unprecedented social and economic disorder. Immediately after the first Covid-19 case was observed in mid-March 2020 in Ethiopia, the government has enacted various economic measures so as to lessen the diverse and dire economic consequences. It has also implemented measures in order to contain the transmission of the pandemic, 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.

Various studies at worldwide, continental, regional and national levels have pointed the asymmetry in the impacts of the pandemic among different groups of populations. In Ethiopia, little is known about the gender and spatial heterogeneity of the pandemic on households' income and various livelihood strategies. This study, therefore, is conducted to examine the heterogeneity in the impacts of Covid-19 on households' total income across gender and regions in Ethiopia.

It has utilized the household level high frequency phone survey (HFPS) conducted by the World Bank in collaboration with the Ethiopian Statistical Agency (CSA) in April 2020. In order to examine the existence of heterogeneity, a logit model containing interaction terms between gender and region dummies and the six Covid-19 containment measures have been fitted on binary outcome of change in total income of households.

Various specification, goodness-of-fit, multicollinearity and influential observations tests are conducted. The results suggest the existence of statistically significant regional heterogeneity in the impacts of within country travel restriction, limit on social gatherings and closure of schools and universities on the change in total income of households.

The remaining three containment measures restriction on international travel, curfew/lockdown and closure of non-essential businesses do not bring heterogeneous impacts across gender and region of households. Overall, gender-based differential impact doesn't exist in all models of containment measures and it is also insignificant factor in determining change in households' total income.

The finds suggest the importance of taking income policy measures that can lessen shocks to household's incomes and livelihood after a pandemic such as Covid-19. It is also important to implement social security schemes that are responsive to members' needs and serve as immediate fallback solutions during such crises. Also, strengthening the savings and borrowing practices with the opportunities, especially for low income earners and rural households, would help them in restoring their businesses and livelihoods. All the measures should take into account the regional heterogeneity in the impacts of the pandemic on household's total income.

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Appendix

Summary statistics of variables

Variable	Obs	Mean	Std. Dev.	Min	Max
gender	3,224	1.304901	.4604368	1	2
age	3,224	41.6067	14.5558	4	100
hhsize	3,224	4.302109	2.216189	1	14
region	3,224	7.936414	5.188114	1	15
in_travel	3,224	.2161911	.4117099	0	1
int_travel	3,224	.0707196	.2563957	0	1
limit_soc	3,224	.7834988	.4119236	0	1
curfew	3,224	.1333747	.340032	0	1
busi_close	3,224	.1439206	.3510636	0	1
schl_close	3,224	.2841191	.4510638	0	1
income_ch	3,224	.560794	.4963673	0	1
own_nfe	3,224	.2996278	.458166	0	1
educ	3,224	.1789702	.5399734	0	3
agec	3,224	2.51e-08	14.5558	-37.6067	58.3933
hhsizec	3,224	-5.42e-09	2.216189	-3.302109	9.697891

Description of model variables

variable name	storage type	display format	value label	variable label
income_ch	float	%21.0g	change	Change in houshold total income after outbreak
gender	double	%3.0g	cs7a_hhh_gender	Gender of the Household Head
age	int	%9.0g		Age of household head
hhsize	byte	%9.0g		Household Size
region	double	%2.0g	cs1_region	Region of Household Location
own_nfe	byte	%8.0g	YN *	Ownership of non farm familiy enterprise
educ	byte	%12.0g	educ	Highest level of education completed
agec	float	%9.0g		Age of household head mean-centred
hhsizec	float	%9.0g		Houshold size mean-centered
in_travel	double	%1.0g	kn3_gov_2	Restricted travel within country/area
int_travel	double	%1.0g	kn3_gov_3	Restricted international travel
limit_soc	double	%1.0g	kn3_gov_10	Stopping or limiting social gatherings
curfew	double	%1.0g	kn3_gov_5	Curfew/lockdown
busi_close	double	%1.0g	kn3_gov_6	Closure of non essential businesses
schl_close	double	%1.0g	kn3_gov_4	Closure of schools and universities

Estimation results of logistic regression: within country travel restriction

income_ch	Coef.	Std. Err.	Z	P>z	[95% Conf.	Interval]
Agec	-.0126459	.0027822	-4.55	0.000*	-.0180988	-.007193
Hhsizec	.0706322	.0195361	3.62	0.000*	.0323422	.1089223
own_nfe	1.32072	.0900191	14.67	0.000*	1.144286	1.497154
_Ieduc_1	.1938755	.1408958	1.38	0.169	-.0822752	.4700261
_Ieduc_2	.5340213	.3214178	1.66	0.097***	-.095946	1.163989
_Ieduc_3	-.682411	.2978406	-2.29	0.022**	-1.266168	-.0986541
limit_soc	.1776652	.0945902	1.88	0.060***	-.0077282	.3630586
_Igender_2	.0305308	.097263	0.31	0.754	-.1601011	.2211626
in_travel	.2941772	.2767938	1.06	0.288	-.2483287	.8366831
_IgenXin_tr_2	.2532022	.2110679	1.20	0.230	-.1604833	.6668876
_Iregion_2	-.8533831	.2791518	-3.06	0.002*	-1.40051	-.3062557
_Iregion_3	-.3453449	.2660063	-1.30	0.194	-.8667076	.1760178
_Iregion_4	.0594702	.2477631	0.24	0.810	-.4261367	.545077
_Iregion_5	1.627568	.3279408	4.96	0.000*	.9848157	2.27032
_Iregion_6	-.3519421	.2732935	-1.29	0.198	-.8875875	.1837032
_Iregion_7	-.4350543	.273683	-1.59	0.112	-.9714631	.1013545
_Iregion_12	-.9433064	.2821886	-3.34	0.001*	-1.496386	-.3902268
_Iregion_13	.1802888	.2668943	0.68	0.499	-.3428145	.703392
_Iregion_14	.005302	.239302	0.02	0.982	-.4637213	.4743252
_Iregion_15	-.2234629	.25822	-0.87	0.387	-.7295649	.2826391
_IregXin_t_2	-.0768253	.4928605	-0.16	0.876	-1.042814	.8891634
_IregXin_t_3	-.5705538	.3603747	-1.58	0.113	-1.276875	.1357676
_IregXin_t_4	-.6471984	.4225902	-1.53	0.126	-1.47546	.1810632
_IregXin_t_5	-.2785578	.8466865	-0.33	0.742	-1.938033	1.380917
_IregXin_t_6	-.2939146	.5031191	-0.58	0.559	-1.28001	.6921807
_IregXin_t_7	-.9998278	.5398588	-1.85	0.064***	-2.057932	.058276
_IregXin_t_12	.3210362	.4962255	0.65	0.518***	-.6515478	1.29362
_IregXin_t_13	-.0786255	.3918808	-0.20	0.841	-.8466977	.6894468
_IregXin_t_14	-1.177335	.5511019	-2.14	0.033**	-2.257475	-.0971954
_IregXin_t_15	-1.635957	.4441366	-3.68	0.000*	-2.506448	-.765465
_cons	-.1531189	.2370109	-0.65	0.518	-.6176517	.311414

*Note: *, **, *** refers to 1%, 5% and 10% significance levels, respectively.*

Estimation results of logistic regression: international travel restriction

income_ch	Coef.	Std. Err.	Z	P>z	[95% Conf.	Interval]
Agec	-.0131807	.0027752	-4.75	0.000*	-.0186199	-.0077415
Hhsizec	.0701653	.0195177	3.59	0.000*	.0319114	.1084193
own_nfe	1.327134	.0898502	14.77	0.000*	1.151031	1.503237
_Ieduc_1	.1807194	.1416525	1.28	0.202	-.0969144	.4583532
_Ieduc_2	.5391218	.3192283	1.69	0.091***	-.0865541	1.164798
_Ieduc_3	-.7245166	.3013952	-2.40	0.016**	-1.31524	-.1337929
limit_soc	.1633964	.0949012	1.72	0.085***	-.0226066	.3493995
_Igender_2	.0552456	.0899554	0.61	0.539	-.1210637	.231555
int_travel	1.119431	.2983661	3.75	0.000*	.5346446	1.704218
_IgenXint_t_2	.3524145	.383953	0.92	0.359	-.4001195	1.104949
_Iregion_2	-.6123115	.2185951	-2.80	0.005*	-1.04075	-.1838728
_Iregion_3	-.233451	.1945166	-1.20	0.230	-.6146966	.1477946
_Iregion_4	.1821453	.1867095	0.98	0.329	-.1837986	.5480892
_Iregion_5	1.720899	.2801353	6.14	0.000*	1.171844	2.269954
_Iregion_6	-.1746462	.2158152	-0.81	0.418	-.5976363	.2483439
_Iregion_7	-.3387573	.2164451	-1.57	0.118	-.7629819	.0854674
_Iregion_12	-.7229853	.2267543	-3.19	0.001*	-1.167416	-.278555
_Iregion_13	.409301	.203545	2.01	0.044**	.0103602	.8082418
_Iregion_14	.1637901	.1794578	0.91	0.361	-.1879406	.5155209
_Iregion_15	-.2247639	.1969226	-1.14	0.254	-.6107251	.1611973
_IregXint__3	-1.685524	.7708507	-2.19	0.029**	-3.196364	-.1746849
_IregXint__4	-.0611407	.7400659	-0.08	0.934	-1.511643	1.389362
_IregXint__6	-.6223433	.9527306	-0.65	0.514	-2.489661	1.244974
_IregXint__7	-.5582009	1.009207	-0.55	0.580	-2.53621	1.419808
_IregXint__12	-.2886834	.6327335	-0.46	0.648	-1.528818	.9514515
_IregXint__13	-.7267425	.5891048	-1.23	0.217	-1.881367	.4278817
_IregXint__14	-1.775153	.8396528	-2.11	0.035**	-3.420842	-.1294635
_IregXint__15	-2.680309	1.233064	-2.17	0.030**	-5.09707	-.2635482
_cons	-.3328143	.1722773	-1.93	0.053	-.6704716	.004843

*Note: *, **, *** refers to 1%, 5% and 10% significance levels, respectively.*

Estimation results of logistic regression: limit on social gatherings

income_ch	Coef.	Std. Err.	Z	P>z	[95% Conf.	Interval]
Agec	-.0131649	.0027721	-4.75	0.000*	-.0185981	-.0077316
Hhsizec	.0687806	.0195223	3.52	0.000*	.0305176	.1070437
own_nfe	1.307396	.0896727	14.58	0.000*	1.131641	1.483151
_Ieduc_1	.2279866	.1409267	1.62	0.106	-.0482246	.5041978
_Ieduc_2	.5634351	.3204813	1.76	0.079***	-.0646967	1.191567
_Ieduc_3	-.6769998	.2959664	-2.29	0.022**	-1.257083	-.0969164
in_travel	-.1028325	.1065763	-0.96	0.335	-.3117182	.1060531
_Igender_2	.0482333	.173505	0.28	0.781	-.2918303	.3882969
limit_soc	.821452	.2775485	2.96	0.003*	.277467	1.365437
_IgenXlimit_2	.0468856	.1966747	0.24	0.812	-.3385896	.4323609
_Iregion_2	-.4663202	.3335412	-1.40	0.162	-1.120049	.1874085
_Iregion_3	-.2605618	.328831	-0.79	0.428	-.9050587	.3839351
_Iregion_4	.1760181	.331222	0.53	0.595	-.4731652	.8252014
_Iregion_5	.9800057	.5464183	1.79	0.073***	-.0909546	2.050966
_Iregion_6	-.2132386	.43258	-0.49	0.622	-1.06108	.6346027
_Iregion_7	-.7123085	.4304461	-1.65	0.098***	-1.555967	.1313503
_Iregion_12	-.6720786	.3842587	-1.75	0.080***	-1.425212	.0810546
_Iregion_13	.6045106	.4197882	1.44	0.150	-.2182592	1.42728
_Iregion_14	.588714	.3008508	1.96	0.050**	-.0009429	1.178371
_Iregion_15	-.6477059	.3470531	-1.87	0.062***	-1.327918	.0325057
_IregXlimi_2	-.986884	.4132277	-2.39	0.017**	-1.796795	-.1769725
_IregXlimi_3	-.6745435	.3834434	-1.76	0.079***	-1.426079	.0769917
_IregXlimi_4	-.6772498	.3766057	-1.80	0.072***	-1.415383	.0608839
_IregXlimi_5	.3043886	.6187935	0.49	0.623	-.9084243	1.517202
_IregXlimi_6	-.6529306	.4819243	-1.35	0.175	-1.597485	.2916237
_IregXlimi_7	-.2521624	.4843127	-0.52	0.603	-1.201398	.6970732
_IregXlimi_12	-.6755674	.4521747	-1.49	0.135	-1.561814	.2106787
_IregXlimi_13	-.8859034	.4636693	-1.91	0.056***	-1.794679	.0228718
_IregXlimi_14	-1.287102	.3442953	-3.74	0.000*	-1.961908	-.6122954
_IregXlimi_15	-.1960028	.3988495	-0.49	0.623	-.9777334	.5857279
_cons	-.2785733	.2459108	-1.13	0.257	-.7605496	.2034031

*Note: *, **, *** refers to 1%, 5% and 10% significance levels, respectively.*

Estimation results of logistic regression: curfew main effect model

income_ch	Coef.	Std. Err.	Z	P>z	[95% Conf.	Interval]
agec	-.01324	.0027653	-4.79	0.000*	-.0186598	-.0078202
hhsizec	.0679147	.0193906	3.50	0.000*	.0299099	.1059196
gender	.0864738	.0874082	0.99	0.323	-.0848432	.2577908
own_nfe	1.320792	.0895396	14.75	0.000*	1.145298	1.496287
_Ieduc_1	.1625278	.1412404	1.15	0.250	-.1142984	.4393539
_Ieduc_2	.4944235	.3193921	1.55	0.122	-.1315735	1.120421
_Ieduc_3	-.7684642	.296425	-2.59	0.010*	-1.349447	-.1874818
_Iregion_2	-.8711185	.2052223	-4.24	0.000*	-1.273347	-.4688902
_Iregion_3	-.5168236	.1764786	-2.93	0.003*	-.8627154	-.1709318
_Iregion_4	-.0897332	.1653076	-0.54	0.587	-.4137302	.2342637
_Iregion_5	1.514214	.2656745	5.70	0.000*	.9935014	2.034926
_Iregion_6	-.4365434	.1983255	-2.20	0.028**	-.8252543	-.0478326
_Iregion_7	-.562092	.2018177	-2.79	0.005*	-.9576475	-.1665366
_Iregion_12	-.9253194	.2049434	-4.51	0.000*	-1.327001	-.5236377
_Iregion_13	.119536	.1813346	0.66	0.510	-.2358733	.4749453
_Iregion_14	-.0955287	.1621216	-0.59	0.556	-.4132812	.2222237
_Iregion_15	-.5146117	.1798117	-2.86	0.004*	-.8670362	-.1621871
limit_soc	.1873733	.0935913	2.00	0.045**	.0039377	.3708089
curfew	.4528482	.1268571	3.57	0.000*	.2042129	.7014834
_cons	-.2077498	.1994165	-1.04	0.298	-.5985989	.1830993

*Note: *, **, *** refers to 1%, 5% and 10% significance levels, respectively.*

Estimation results of logistic regression: closure of non-essential businesses

income_ch	Coef.	Std. Err.	Z	P>z	[95% Conf.	Interval]
Agec	-.013157	.0027719	-4.75	0.000*	-.0185899	-.0077241
Hhsizec	.0705265	.0195221	3.61	0.000*	.0322639	.1087892
own_nfe	1.308292	.0895644	14.61	0.000*	1.132749	1.483835
_Ieduc_1	.2005075	.1408825	1.42	0.155	-.0756172	.4766321
_Ieduc_2	.514989	.3215513	1.60	0.109	-.1152401	1.145218
_Ieduc_3	-.6835373	.295266	-2.31	0.021**	-1.262248	-.1048266
limit_soc	.1790606	.0941302	1.90	0.057***	-.0054313	.3635525
_Igender_2	.0312791	.0930151	0.34	0.737	-.1510271	.2135853
busi_close	.4873488	.2688853	1.81	0.070***	-.0396567	1.014354
_IgenXbusi__2	.3641977	.2548506	1.43	0.153	-.1353003	.8636957
_Iregion_2	-.8760862	.2351566	-3.73	0.000*	-1.336985	-.4151877
_Iregion_3	-.461498	.204623	-2.26	0.024**	-.8625518	-.0604442
_Iregion_4	-.0460801	.1898122	-0.24	0.808	-.4181051	.325945
_Iregion_5	1.380929	.2835234	4.87	0.000*	.8252334	1.936625
_Iregion_6	-.3551238	.2189348	-1.62	0.105	-.7842281	.0739805
_Iregion_7	-.5055819	.2182784	-2.32	0.021**	-.9333996	-.0777642
_Iregion_12	-.8432556	.2303872	-3.66	0.000*	-1.294806	-.391705
_Iregion_13	.1385462	.2149258	0.64	0.519	-.2827005	.559793
_Iregion_14	-.0284622	.1825098	-0.16	0.876	-.3861748	.3292504
_Iregion_15	-.4617069	.1993437	-2.32	0.021**	-.8524134	-.0710004
_IregXbusi_2	-.382916	.4562373	-0.84	0.401	-1.277125	.5112927
_IregXbusi_3	-.5484305	.3835379	-1.43	0.153	-1.300151	.20329
_IregXbusi_4	.1184344	.5053328	0.23	0.815	-.8719996	1.108868
_IregXbusi_6	-.8431315	.6805885	-1.24	0.215	-2.17706	.4907974
_IregXbusi_7	-1.582819	.9665036	-1.64	0.101***	-3.477131	.3114936
_IregXbusi_12	-.6467627	.5418351	-1.19	0.233	-1.70874	.4152146
_IregXbusi_13	-.1829274	.3951824	-0.46	0.643	-.9574708	.5916159
_IregXbusi_14	-1.02623	.4843314	-2.12	0.034**	-1.975502	-.0769576
_IregXbusi_15	.0015865	.9163304	0.00	0.999	-1.794388	1.797561
_cons	-.1272684	.1763372	-0.72	0.470	-.472883	.2183462

*Note: *, **, *** refers to 1%, 5% and 10% significance levels, respectively.*