Research Article

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Assessment of the Impact of COVID-19 Pandemic on Economic Performance: DSGE and Probit Investigations

Hind Alofaysan[1]

Fatma Mabrouk[1,2*]

Jihen Bousrih[1,3]

[1]*Department of Economics, College of Business and Administration, Princess Nourah bint Abdulrahman University, P.O. Box 84428, Riyadh 11671, Saudi Arabia*
[2]*Bordeaux School of Economics (BSE), University of Bordeaux, France*
[3]*Laboratory of Business and Economics Statistics Modeling (BESTMOD), Tunisia*
** Corresponding Author*

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Abstract

The paper proposes an innovative microeconomic analysis of the effects of COVID-19 on the economic performance by relying on two different approaches. Firstly, we consider a theoretical investigation by implementing a DSGE model where we propose a negative health shock on the supply part of the economy. The second approach is based on empirical investigation via Ordered Probit Regressions using the Saudi Labour Force Survey where we focus on time and regional effects by comparing 2019 and 2020 indicators. On one side, our findings reveal that health shock impacts household health spending. An affected household by the COVID-19 will see its resources decreasing due to the indirect costs of the pandemic related to the loss in productivity and labour supply. It is much more than that the COVID-19 pandemic hurts working hours and earnings. On the other side, the results show that individuals with higher degree of schooling and high skills seem to be not affected during the pandemic. Additionally, the effect of the current health crisis is more noticeable in Riyadh, Southern and Western region and is more intensive in the private sector and for non-Saudi workers.

Keywords: *DSGE models, Probit Approach, Pandemic Costs, Economic Performance, Health Shock*

1. Introduction

Assessing the impact of the COVID-19 pandemic on markets is fundamental to tailor responses to governments and to quickly recover from the resulting crisis. In a constantly changing environment, it is not easy to evaluate the extent of the economic impact. However, it is clearly recognized that they cause strong contractions of the level of production, household expenditure, investment, and labour market structure. The COVID-19 pandemic has generated worries of an economic crisis and

recession in the current integrated world. Governments have adopted effective public health measures such as social distancing, quarantine, school closures and travel restrictions to slow down the growth of new infections. These non-medical measures distort economic activities, (Eichenbaum, Rebelo, and Trabandt, 2020; Baldwin and Weder di Mauro, 2020) and have disturbed supply chains and activity in manufacturing and service sectors which resulted in lost jobs and declines in the amount of workforce across all sectors (Atkeson, 2020). Furthermore, the global stock markets collapsed, and the rate of unemployment rose to extraordinary levels. As reported by the international labour organization that more than 8% of total working hours were gone in 2020, relative to the last quarter of 2019. In other words, working-hour losses in 2020 were nearly four times greater than those caused by the 2009 global financial crisis.

Among the GCC countries, Saudi Arabia is the largest economy. Its economy heavily relies on sectors that have been greatly impacted by the lockdown during the pandemic such as the petroleum sector and religious tourism. Therefore, it becomes an interesting case to evaluate the impact of the current pandemic on economic performance. In fact, exceptional precautionary rigorous procedures were applied to limit the propagation of the virus. In this paper, we review the responses of Saudi Arabia to the pandemic. Saudi Arabia has registered more than 546.000 confirmed cases and more than 8679 deaths according to World Health Organization report 2021. The government has adopted key procedures to minimize the spread of the COVID -19, proceeded at various levels to implement the social distancing at an early stage. The government has also suspended travel flights, religious, social and entertainment gatherings. The aim was to implement a safe environment despite the social, economic, and political consequences of such actions (Yezli and Khan, 2020).

In view of the above background, this research addresses important issues related to the impact of the recent pandemic; what are the real economic impact of the COVID-19 pandemic on Saudi Arabian economy? The economic effects are temporary or persistent? Does nationality, gender, level of education, institutional sector, or geographical regions matter?

The study adopts a microeconomic foundation based on two main approaches, a theoretical model, and an empirical investigation. In the theoretical model, we use a Dynamic Stochastic General Equilibrium model (DSGE model) to simulate the economic costs of COVID-19 by introducing a negative health shock on the supply part of the economy as a decrease in labour utilization with unaffected labour cost to measure the losses related to this pandemic. The empirical analysis evaluates the effect of COVID-19 on different indicators across regions using the Labour Force Surveys (LFS) 2019-2020 published by the Saudi General Authority for Statistics (Gstat).

The research emphasis some solid indicators associated with the labor market today and explore the development of the labor market by identifying solid indicators during the COVID-19 context.

This paper greatly contributes to the recent literature on the economic impact of COVID-19 pandemic in two main aspects. First, it examines the impact of the pandemic on the economic performance of Saudi Arabia as case study, using simultaneously theoretical and empirical approaches. Second, as most of the empirical studies in the literature are based on macroeconomic panel data and consider common results for all countries under investigation although they are heterogeneous, our research depends on an original data from the Saudi LFS and considers a case study exploration. To our knowledge, this paper is the first to use this type of data where we set ourselves apart from the previous literature on the econometric methodology which compares the data in terms of cross section analysis and regions.

The paper is organized as follows: First, we introduce the main idea of the paper, Section 2 presents the literature review. Section 3 discuss the theoretical approach using a DSGE model. Section 4 describes the data and the methodology adopted in the paper, followed by the Conclusions and policy implications in section 5.

2. Literature Review

The effect of epidemics has been greatly discussed in the economic literature. The studies have estimated the economic costs of an epidemic based on private and non-private medical expenses linked with the illness, such as expenditure on diagnostic and treatment (Lee and McKibbin, 2004). Losses of time and income on medical care are added to obtain the estimate economic cost of any disease. McKibbin and Fernando (2020) argue that this conventional approach underestimates the true economic costs of any disease which is highly transmissible (such HIV/AIDS, SARS and pandemic influenza). The results of such policy on previous disease outbreaks provide important information on how to consider the COVID-19 implications.

After the SARS and H1N1 episodes respectively in 2003 and 2009, the researchers greatly recognize the importance of the short- and long-term consequences of a pandemic on the economy. The first impact is a negative shock on population and labour force. Surprisingly, the COVID-19 pandemic seems to be different and unique in several aspects: it is global, affecting countries of all income levels, interest rates at historically low levels, the world is much more integrated, the pandemic is generating spill over effects throughout supply chains, and it has simultaneously destruct demand and supply (Fernandes, 2020; Glocker and Piribauer (2021)).

According to Acemoglu and Johnson (2007), a disease that kills kids and old people without any strong effects on active population aged between 15 to 56 years old can produce an initial improvement in GDP. Similar findings of Barro and Sala Martin (1995) confirm a negative shock to population expansion can lead to a quick accumulation of capital and a quick output growth. Conversely, a reduction in labour force will lead to a slower capital accumulation and thereby lower output growth. Nevertheless, the case is not the same with the COVID-19 pandemic as it affects all the population in different age groups so its long-term economic consequences are not explicit.

Baldwin et al (2020, a) argue that the global reduction in growth rates due to the COVID-19 pandemic through the first quarter of 2020, is driven by a sharp deterioration in private consumption (transport, leisure and retail trade), in industrial activity for several sectors and in global trade. A prolonged constrained trade policy around the world will damage the investment and demand for capital goods as well (The World Economy-IMF Report, 2019).

According to Baldwin et al (2020, b), the social distancing policies imposed by several governments to reduce the spread of the virus significantly impacted the amount of labour which in turn is significantly lowering global output. These findings are confirmed by Barrot, Grassi, & Sauvagnat, 2020; Koren & Peto, 2020. Such policies have an economic cost of cumulative loss of working hours or otherwise, if not implemented, large loss of lives due to the contamination of the disease (Ferguson et al., 2020). The only approach to ensure continuity of work with the minimum risk of the pandemic is working from home which found to be linked with an increase of income inequality among employees since it would more benefit male, older, graduated, and high-paid employees (Bonacini et al., 2021). Self-employed are more prone to a decline in their levels of subjective well-being compared to paid workers due to the disproportionate decreases in working hours and income (Yue and Cowling, 2021)

COVID-19 pandemic causes a heterogeneous impact on employment across European countries. Part-time employees, young and low education level workers were the most affected. Activity sectors such as trade, transport and recreation have been disproportionately affected, with the largest decreases in hours worked (Anderton at al., 2021). In countries with high inequality rates, COVID-19 crisis may lead to large scale job losses, loss of income, increased poverty, and intensified inequalities in the labour market (Kapoor, 2020, Miyamura, 2021). Building upon the experience from assessing the economics of SARS (Lee & McKibbin 2004) and Pandemic Influenza (McKibbin & Sidorenko 2006, 2009), McKibbin and Fernando (2020) attempt to measure the total economic costs of COVID-19 under different scenarios and conclude that service-oriented economies are more harmfully affected by the pandemic than others. Countries that are heavily reliant on tourism and foreign trade have a large negative effect on their labour markets. Overall, each additional month of crisis damages

2.5-3% of global GDP (Fernandes, 2020).

Regarding the Saudi economy, Bachar at al., (2021) develop a mathematical model to predict the expand of the corona virus by dividing the individuals into time dependent compartments (low risk, high risk, exposed, infected, recovered). The authors present a simulation on the persistence and the constancy in the number of these individuals with the control policies adopted by the government during the pandemic. Sayed and Eledum (2021) shows evidence that the most depressingly affected industry groups are banks, consumer services, capital goods, transportation, and commercial services. Similarly, Gali (2020) finds that the direct loss of GDP through the decline in consumption of goods and services will increase by the presence of the indirect effects if the decrease in output leads to unemployment and then loss of income. Despite the high number of inactive workers, firms will try to keep their payroll unchanged and pay their fixed expenses such as rent and interest during the non-productive period by contracting new loans from banks (McKibbin and Fernando, 2020).

The spread of the virus has devastated the health systems worldwide and caused widespread social and economic disturbances. Governments continue to adopt defensive measures that helps to control some of the short-term impact of the virus.

A study by Coccia (2021, b) reveals that all European countries have no awareness to cope with a major pandemic. Furthermore, countries with reduced size of population, good public governance and well-established health system are among the best countries to cope with the pandemic. Another study by Coccia (2021, a) shows evidence that countries with greater investments in healthcare (as % GDP) have alleviated fatality rate of COVID-19 and instantaneously have applied a quicker period of lockdown, reducing negative effects on economic growth. Similarly, the author underlines the importance of the preventive strategies to strengthen the process of R&D dedicated to efficient vaccines to limit the virus spread. The comparative evaluation of performance with other countries applying alternatives policies seems to be the best strategy to ensure the pandemic prevention. Baniasad at al., (2021) study the association between the virus transmission rate, environmental factors and socio-political parameters and conclude that reducing mobility can lower the virus transmission.

Based on the literature debate, this paper attempts to evaluate the impact of the COVID-19 on the Saudi economy by using two approaches. A theoretical investigation approach using a DSGE model to simulate the economic effects of the COVID-19 where we e introduce a negative health shock on the supply side of the economy as a drop in labour utilization under unaffected labour cost. A drop in working hours will lead to a decrease in the income of consumers lowering its expenditure.

3. Methodology and Data

In this study, we adopt two approaches to get an overall view on the impact of COVID-19 Pandemic on selected Saudi economic performance indicators. The methodology adopted in this research is based on two principles investigations: Dynamic stochastic general equilibrium (DSGE) model and Probit model. The desire to evaluate the impact of COVID-19 on the whole economy in general and on individuals in particular is the principles motivation of using theoretical and empirical analyses.
Without denying the need to mobilize the theoretical approach to evaluate the COVID-19 economic impacts, it is important to emphasize that this approach by itself does not fully identify the whole effects and constitutes half puzzle pieces. Therefore, we propose the second approach to complete this construction. We adopt an empirical analysis based on cross-sectional from the LFS of 2019 and 2020 published by the Saudi Gstat.

To assess the impact of COVID-19 Pandemic on some Saudi economic performance indicators, both approaches complete each other and are mainly focused on productivity change before and during COVID-19.

3.1 Theoretical Investigation: Insights From a Dynamic Stochastic General Equilibrium (Dsge) Model

The virus itself is not as deadly as other microbes like Ebola disease, SARS, AIDS, and Malaria. However, its speed of spread and its enormous pressure on health systems, its effects on the world economy, constitute its strength. The COVID-19 pandemic renewed the concern about the macroeconomic impact of economic crisis.

Brinca et al. (2020) use a dynamic stochastic general equilibrium model (DSGE) to simulate a depression scenario for the COVID-19 crisis in USA. They focus on the effects of a set of policies to reduce the effect on exposed households and firms. Eichenbaum et al. (2020) present a canonical epidemiology (SIR model) in a real business cycle model. The authors endogeneate the dynamics of the pandemic to propose the best possible health policy to be adopted by the policymakers. Baker et al. (2020) adopt a progressive approach to explain the macroeconomic effect of the economic uncertainty produced by the pandemic crisis on the US economy.

Morsy, Balma and Mukasa (2020) use a DSGE model to evaluate the impact of the COVID-19 health crisis on household's well-being in the African economies. The epidemic is simulated as a supply shock that disturbs the economic cycle. It affects household consumption behaviour, household well-being and business investment decisions. The researchers adjust the DSGE model by including the informal part of the economy that is a key feature of African economies. The results show the burden of the pandemic on employment for the formal and informal sectors on one hand, and on the consumption behaviour particularly for the savers on the other hand. These reductions run to an economic collapse in Africa by increasing the budget deficit and the current account deficit leading to an increase in the poverty level of the vulnerable households.

Fornaro and Wolf (2020) present a New Keynesian representative economics' agent and simulate the pandemic as a negative shock to the world economy. The results show a short-lived negative supply shock of the coronavirus. Therefore, the agent's expectations about future growth will not be severely affected and the impact on demand will be small.

An expanding number of articles inspired by the recent COVID-19 pandemic are motivated from the epidemiological Susceptible (Exposed) Infected Removed (SIR) and (SEIR) models. Atkeson (2020) present a SIR model on the evolution of COVID-19 in USA. The author provides several economic implications of the COVID-19 spread by studying the trade-off between the timing and severity of procedures to end the pandemic through social distancing and other restrictive policies. Berger, Herkenhoff and Mongey (2020) extend the baseline SEIR infectious disease epidemiology model to identify the impact of case-dependent quarantine in reducing the economic burden resulting from a pandemic.

The epidemic diseases are expected to constitute an important burden to the economic and social welfare. These seasonal epidemics pulled the global economy into an unexpected situation by exposing the companies and investors to high risk with a loss of revenues and benefits for some firms and the total blockage of the economic activity for others. Rice (1967) distinguishes two sorts of economic losses that occur from a disease: Direct costs are mainly related to medical care spending of public sector to support medical practices, medications, and hospitalization. This is tightly aligned with the common insight of the disease's costs. Indirect costs are related to the productivity losses for a sick individual resulting to a reduction in labour supply.

The outbreak of COVID-19 in KSA has affected the economy through several sectors resulting in losses in production. In fact, the GDP declined by 1.3 and 5.2 respectively in January and July 2020 according to OCDE report (2021). Based on this background, we develop a theoretic extension of a standard set of micro foundations in a general equilibrium framework to estimate the economic losses due to the impact of the COVID-19 pandemic in Saudi Arabia.

We apply a modified version of a Dynamic Stochastic General Equilibrium Model (DSGE) to measure the various costs of illness and its impact on economic performance. The model includes a representative household. According to Bardhan and Udry (1999) and Toroj (2013), we formulate the utility function as follow: $U[C^{nh}, L, S, H(C^h)]$

Where U: one period utility; C: Consumption divided into non-health good and health good; S: consumption of self-produced goods; L: Leisure and H: the stock of household's health.

The utility of the household is derived from time spending in leisure, consumption of health and non-health goods, consumption of home production and stock of health. The relation between utility and the consumption of health good (finance the cost of illness in the model) is not direct. In fact, when the stock of health is affected, the consumption of health good increase. Therefore, since the stock of health is constant and not affected, the household can assign his income to non-health goods.

According to WHO (2010), the macroeconomic and social impact of a disease can be explored through general equilibrium framework with various second order effects. The WHO recommends adopting general equilibrium model to assess the macroeconomic effect of market costs (see figure 1). However, the policy analyses are non-founded on such frameworks and throughout the literature, there are no specific recommendations for using a suitable method to estimate the shortfalls in both market labour and consumption terms.

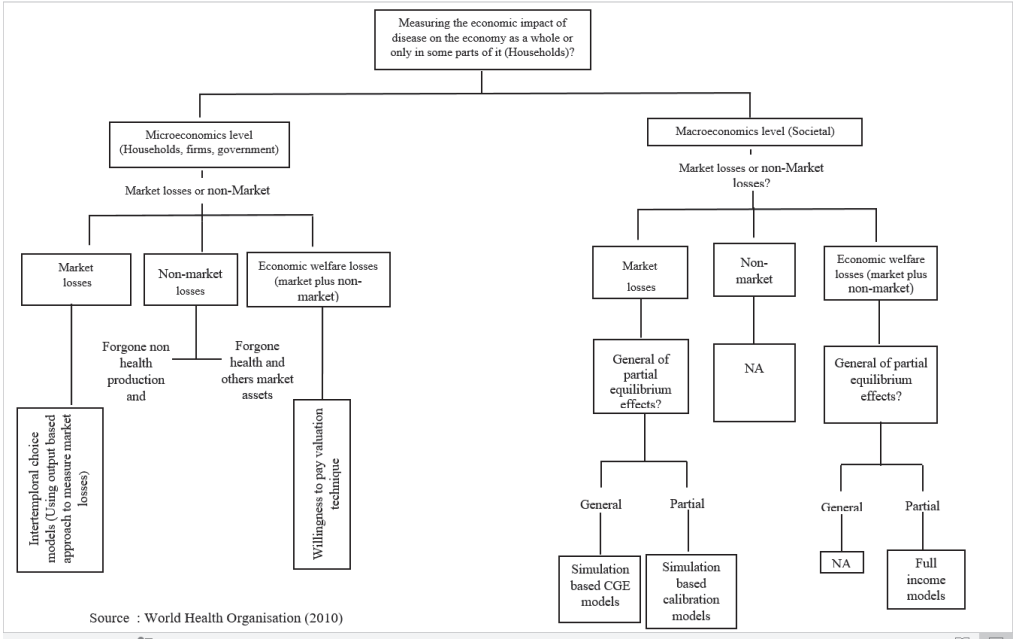

Figure 1 : Measuring the Impact of a Disease On the Economy

In this paper, we tried to challenge this mismatch by proposing a DSGE framework, in which we include a new variable H which is essential when assessing the social impact of market losses due to a disease. In fact, in case of a disease such as the COVID-19 pandemic, the household's health stock can be affected. A negative health shock is represented by ε^H and will affect households in various ways:

- Direct decrease in health stock H=H (C^H, ε^H)
- Reallocation of income from the non-health to health sector. We suppose that we are in a closed economy with no capital and investment, so the income constraint become: $Y = C^{nh} + C^h$
- Loss of time by spending time sick divided into lost working time and into lost leisure time L^{nh}. So, the amount of leisure $L = 1 - N - L^{nh}$ (N is the labor supply and 1 is the amount of time for a given period)

Using a CRRA[1] utility function, we study the economic effects of diminishing leisure, with demand shock ε_t^D, risk aversion σ, labour supply shock ε_t^L and Frisch elasticity of labour supply $\emptyset$. The utility function is formulated as follow:

$$U_t(C_t, N_t) = \varepsilon_t^D \frac{(C_t - hC_t)^{1-\sigma}}{1-\sigma} - \varepsilon_t^L \frac{(N_t + L_t^{nh})^{1+\emptyset}}{1+\emptyset} \quad (1)$$

To write the equation (1), we make two important assumptions. The first one is related to the Frisch elasticity which is constant for the time spend working and the time spend being sick. Whereby, only the first variable is a decision variable. The second assumption is related to the definition of the leisure time which is reduced by the time being sick when visiting doctors, going to the pharmacies.

The model involves a representative firm that generates a final good. The impact of illness often includes the cost of decreasing production as an important economic burden. Several methods, such as in Behar (2015), estimate indirect cost of illness, such as human capital approach or friction cost approach focus on the producer side instead of the household side. The production function is a standard Cobb Douglas version:

$$Y_t = A_t K_t^{1-\alpha} (H_t . N_t)^{\alpha} . \varepsilon_t \quad (2)$$

A: Labour productivity; K: capital stock, ε_t: supply shock and α is the Cobb Douglas exponent for labor. The marginal product of labour is represented by the equation (3) below:

$$MPN_t = \frac{\partial Y_t}{\partial N_t} = A_t K_t^{1-\alpha} \alpha N_t^{\alpha-1} \varepsilon_t H_t^{\alpha} \quad (3)$$

The log linearization of the expression[2] (3) define the expression of the real marginal cost given by the equation (4)

$$mc_t = w_t - p_t - a_t + (1-\alpha)k_t + (\alpha - 1)n_t + \epsilon_t + \alpha h_t \quad (4)$$

We calibrate the model using parameters for Saudi Arabia obtained from the literature. Table 1 presents the parameters applied in the model.

Table 1: Calibration parameters

Parameter	Value	Description
α	0.128	Cobb Douglas Exponent for Labour, Blasquez (2021)
σ	0.9615	Discount Factor, Blasquez (2021)
$\emptyset$	0.669	Frisch Labour supply elasticity, Behar (2015)

3.2 *Empirical Investigation: Insights from Ordered Probit Regressions*

Data employed in this section are obtained from the Saudi LFS Q2-2019 and Q2-2020 published by Gstat. Q2-2019 sample covers 12,263 families whereas Q2-2020 sample covers 7,957 families, among which 8,511 and 4,289 respectively are not included in the category of receiving income.

For the dependent variable we use the question below from the LFS "What is the net monthly wage (cash and other) that (the individual …) received in the last month of his main work?". We rearrange this variable in four categories:

0- Not included as an income receiver (Basic-Reference)
1- Low income [0 - 4999]
2- Middle income [5000 - 9999]
3- High income > 10000

[1] *The Constant Relative Risk Aversion function lead to the percentage change in hours worked due to the percentage changes in wages as equal to the intertemporal elasticity of labour supply.*
[2] *Log linearization:* $mpn_t = a_t + (1-\alpha)K_t + (\alpha - 1)n_t + \epsilon_t + \alpha h_t$

Table 2: Income Distribution from the Q2- 2019 to Q2- 2020

Income Categories	Q2-2019	Q2-2020
No income	8511	4289
Low income [0 - 4999]	1821	1677
Middle income [5000 - 9999]	982	953
High income > 10000	949	1038
Total	12263	7957

Source: Authors' calculations based on LFS Q2-2019 and Q2-2020 published by Gstat, Saudi Arabia.

Table 2 presents the distribution among the different income levels in 2019 and 2020. The classification seems to be similar except for the reference category, we have 8511 for 2019 and 4289 for 2020.

The following describes the details of all the independent data used in the model.

Variable definition	Variable description
Gender	Gender of respondent (Male /Female) 1 if Male, 0 if female.
Age	Age, age squared.
Nationality	1 if Saudi, 0 if Non Saudi.
Marital status	1 if Married, 0 if not married
Qualification	1-Illiterate & Primary or elementary school/ 2- Intermediate and secondary school/ 3- High School.
Institutional sector	What institutional sector does the individual work for? 1 if private sector, 0 if non private sector.
Productivity- Working hours' change	Have business hours changed during the Coronavirus (COVID-19) pandemic? 1 if Yes, 0 if No.
Regional Dummy	Regions: 3 regions 1-Capital : Riyadh 2-North and East region: Aljouf, Northern border, Alqaseem, Eastern region, Tabouk, Hail. 3-Southern and western region: Albaha, Almadinah, Jazan, Asseer, Makkah, Najran.

The Ordered Probit Model implies that marginal effects must be considered in interpreting results. To test the results robustness, we estimate several income functions which include different aspect of time and regional factors.

The income variable is identified as a dependent variable. It is cardinal measure and considered as a score and simple linear regression model Ordinary Least Squares appropriate for the chosen model:

$Z_i = \alpha + \beta B_i + \varepsilon_i$

where Z_i is a cardinal measure of income and B_i is a vector of independent variables. However, economists used to assume an ordinal form by treating the dependent variable as an ordered set of income levels. Under the ordinarily assumption, ordered Logit or Probit models assuming a continuous and latent measure of the dependent variable which is given by:

$Z_i^* = \alpha + \beta B_i + \varepsilon_i$

where Zi* is a latent variable and what is observed is different categories of an ordered categorical variable:

i=1; Low income

i=2; Middle income

i=3; High income

We estimate two Ordered Probit Regressions: Model (1) first model investigates the impact of

independent variables on income distribution for the Q2-2019. Model (2) use the same specification for the period Q2-2020 to compare the impact before and during the Covid-19 pandemic. Models 3-4- and 5 estimate the same equation (2) by introducing regions subgroups for Q2-2020. We consider 3 regions:

1. Capital : Riyadh
2. Northern and Eastern region
3. Southern and western region

Table 3: Income distribution Q2- 2020 by regions

Income Categories	Capital	North and East Region	Southern and Western Region
No income	47%	52%	57%
Low income [0 - 4999]	19%	23%	20%
Middle income [5000 - 9999]	16%	12%	11%
High income > 10000	18%	13%	11%
Total	13%	39%	48%

Source: Authors' calculations based on Labour Force Survey Q2-2020 published by General Authority for Statistics-Saudi Arabia (2020)

Table 4 in Appendix shows the correlation matrix where there is no detection of multi-collinearity problem at the level of 5%.

4. Results and Discussions

The results of the two approaches provide a complete understanding of the impact of covid 19 pandemic on the economic performance of Saudi Arabia from macro and micro perspectives.

The common finding derived from the two adopted investigations is the negative implications of COVID 19 on productivity. In fact, the pandemic negatively affects the labor productivity mainly through the sickness effect and the hospitalization of the worker, which will reduce the number of working hours and led to a productivity loss over the period of sickness.

The following subsections present the results of the two methods used by highlighting the impact of the pandemic on the different macro and microeconomic indicators.

4.1 DSGE Model results

After proceeding to the calibration of the model, we run the simulations by disturbing the steady state equilibrium in period zero and we trace the impulse model's responses over sixty periods. We apply a negative shock, similar to the pandemic, on the exogenous variable health stock "h", and we simulate the reaction of several variables in the model such as the consumption of health and non-health goods, the production, the capital, the leisure and the labour.

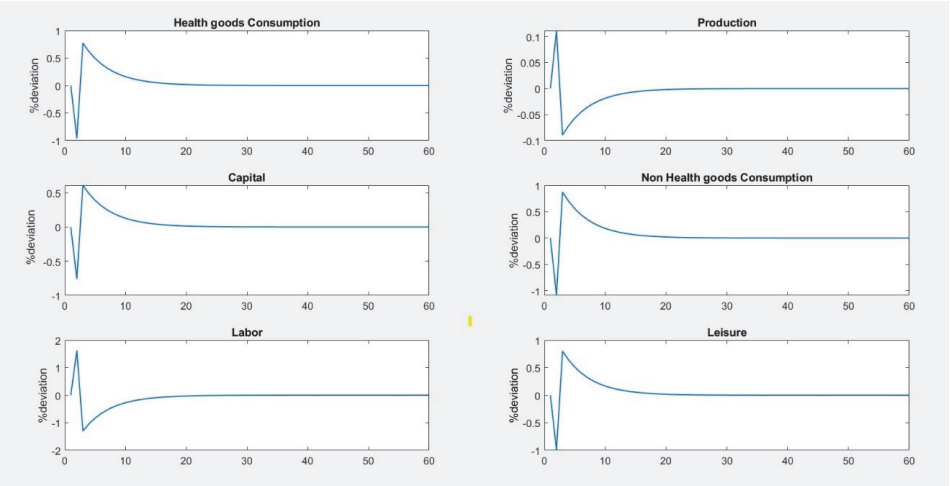

Figure 2: Impulse Responses of a Negative Health Shock
Source: Author's simulation using MATLAB.

In this scenario (Figure 2), the results show a lagged response for all the variables. In fact, the reaction to the negative shock in the health stock started after 2 periods. These lags are due to the virus incubation period, the time gap between the infection by the COVID-19 virus and the apparition of the first symptoms, Pak et al. (2019).

Once the stock of health is affected, the household will spontaneously increase his consumption of health goods such as buying medicines or visiting doctors. The first figure confirms this fact and we record an increase by 1% of the health good consumption, Mihailov (2020). Regarding the consumption of non-health goods, our simulation reveals an increase by 1% due to the implementation of new habits among population due to the restrictions in movement and trade. The COVID-19 pandemic has speeded the move towards a more digital world and pushed lot of persons to do their shopping online as many retails were closed due to the lockdown procedures. Salem et al (2020) focuses on the factors that motivate Saudi consumers to adopt the e-commerce for the shopping of daily goods and services rather than the traditional way. Alhusseini (2020) present another explanation to the increase of the non-health consumption. Using a study on Riyadh residents during the COVID-19 pandemic, he concludes that due to the awareness of people about the balanced food to boost the immune system and fight the virus, many people increase their consumption (by online orders) of healthy diet goods. Many other studies focus on the boom in consumption of online services. Moreover, in the Middle East region, some entertainment companies such as Netflix records the best quarter considering the number of subscribers for the COVID-19 pandemic period.

The pandemic impacted the working-age individuals and working hours in the job market due to the risk of contamination and death in the COVID-19 lockdown. The impulse response of the labour shows a decrease in the quantity of labour supplied affecting the production, (Dingel and Neiman, 2020). In fact, the lockdown restrictions impose "online work" procedures which present less productivity and less working hours. This led to a sharp decrease in the production affecting the consumer revenue. These findings are confirmed by Anderston et al. (2021) and Gali (2020).

Toward this situation, Saudi Arabia implements several actions to support the drop in revenue due to the decrease in labour hours and production. The government announced several funding packages for the private sector which is the most affected one by the pandemic compared to the public sector such as releases of some government charges, funding the banking and SME sectors and

allowance to the private sector to guarantee that the consumer revenue will not be affected by the pandemic.

Finally, the impulses responses show a smooth increase in the capital. The digital transformation of some companies enhances their competitiveness and enable them to grow in an efficient and resilient way. During 2020, approximately 19 applications and platforms were launched by several Saudi businesses to support the public health sector. Huge efforts were done to develop an e-learning process in the Saudi education sector, promoting national and international companies such as zoom, Microsoft and Blackboard. Finally, the communication sector in KSA have seen their capital increasing due to their prime role in supporting consumers during the lockdown period.

4.2 PROBIT Model results

Despite its relative lack of value, the Pseudo R^2 shows a stable degree of variables explanation from model 1 to model 5 and estimated around 30% to 40 % (Table 5 and 6). Thus all models have a significance of 1% (Prob > chi2 = 0.000). Results are stable as most of the variables are significant except the Marital status.

From Table 5, Gender, Age, Age^2, High School, Institutional Sector-Private sector and Working hours' change are statistically significant in models (1) and (2). Results reveal a positive association between Gender, Age, High School with high and middle-income levels. Men are in the middle and high- income level of 8% and 4.6% in 2019 and 11% and 9% in 2020 respectively which shows resilience of men in facing COVID-19. These results are confirmed by Lazarus (2021) and Pinchoff (2021).

Results from Table 7 in Appendix show that as a person is getting older is in the middle and high- income level, Kochhar et Cilluffo (2018). A one-point increase in age consequences in 3% and 2.2% augmentation in the probability of being respectively in the middle and high-income levels for 2019. Another interesting finding, similar to the results of Adamczyk (2020), is that the probability decreases in 2020 to move from 3% to 1.8% for the middle- income level and doesn't change for the high- income level. The change from 2019 to 2020 shows that age has a stable impact with high-income level.

Education has the sturdiest influence on income level. Consistent with model (1), people who accomplished a higher degree of education are respectively 1.5% and 3.4% more likely to be in the middle and high-income levels. An amazing result derives from model (2) showing a negative variation of the variable high school (from 1.5% to 0.9%) in the probability to be in the middle-income level and a positive variation from 3.4% to 4.1% in the probability to be in the high-income level. Our findings emphasize that a one-point increase in high schooling results in a rise in the probability of being in the high-income level during the COVID-19. People with a higher schooling seems to be not affected during the COVID-19. Quite the contrary, the pandemic plays a role of positive externality for them. In fact, this confirms IZA Expert- Panel Survey analysis, that the short-term employment changes for high-skilled and permanent employees is marginal whereas the negative impact is more pronounced for low-skilled workers.

Results show that a one-point increase in the probability of being in the private sector leads to 6.2% (2019) and 5.3% (2020) augmentation in the probability of being in the low -income level. There are two possible explanations; on the one hand, new economic sectors required skills and qualifications for the private sector and the motivations for workers to get attractive salaries. They highlighted the necessity to ensure that salaries are positively correlated with productivity and that labour market strategies should emphasis on setting clear expectations about the limited employment prospects in the public sector, reinforcing education and training, and increasing female participation. This finding was widely discussed by Kalaylıoğlu et al., (2020). On the other hand, the pandemic caused delays to many Saudi Vision Realization Programs spending plans in 2020.

A person who has had working hours' change during the COVID-19, is significantly more likely to be in the low-income level. A one-point change in the working hours' leads to +1% and -0.6% in

the probability of being in the low-and high-income levels respectively. The COVID-19 pandemic is having a negative effect on working hours and earnings.

Introducing the regional aspect helps to provide a greater investigation of COVID-19 impacts on Saudi Economy. This subsampling implicates a modification in the significance and marginal effects of some variables. Similarly, to Gray et al., (2020) and Patel et al., (2020), the objective of Models 3-4 and 5 (Table 6) is to compare the regional impact of COVID-19 pandemic. Results record that all the variables are statistically significant except the Marital status and keeping the same sign of significance but with different level of values. Related to Table 6, Gender, Age, Nationality, Intermediate and High School, have a positive association with income distribution during the COVID-19. However, the private sector and working hours' change are negatively connected. The effect is more noticeable in Riyadh, Southern and Western region and is more intensive in the private sector and for foreign workers.

Table 5: Income distribution before and during COVID-19

	Model 1	**Model 2**
	Q2-2019	Q2-2020
Gender	**0.3392***** (0.0551)	**0.5194***** (0.0567)
Age	**0.1428***** (0.01277)	**0.1040***** (0.0140)
Age²	**-0.0018***** (0.0001)	**-0.0012***** (0.0001)
Nationality	-0.0296 (0.0695)	0.2565*** (0.0638)
Marital status	0.0559 (0.0513)	0.0675 (0.0544)
Intermediate and secondary school	-0.0676 (0.0445)	0.4867*** (0.0472)
High School	**1.4499***** (0.0751)	**1.5277***** (0.0685)
Institutional Sector-Private sector Working hours' change	**-2.1217***** (0.0751) - -	**-1.6903***** (0.0637) **-0.2828***** (0.0376)
The cut off points		
Cut 1	-0.4947* (0.2776)	-0.2988 (0.2900)
Cut 2	1.7908*** (0.1836)	1.9644*** (0.3018)
Cut 3	3.1844*** (0.2849)	3.2388*** (0.3067)
Nb. Obs.	4049	3885
Log pseudolikelihood	-3176.0926	-3181.0147
Wald χ^2 (p. value) Percentage-cases correctly predicted	2198.36 0.0000 71.7%	2585.89 0.0000 69%
Pseudo R^2	0.3647	0.3295

Notes: Robust standard-errors are reported into brackets. Levels of statistical significance: ***p < 0.001, **p < 0.05, *p < 0.1.

Source: Authors' calculations based on Labour Force Survey Q2-2019 and Q2-2020 published by General Authority for Statistics-Saudi Arabia (2019 & 2020).

Table 6: Income distribution by regions during COVID-19

	Model 3	Model 4	Model 5
	Capital Riyadh	North and East region	Southern and Western region
Gender	0.7711*** (0.1414)	0.4203*** (0.0880)	0.5607*** (0.0905)
Age	0.1759*** (0.0416)	0.0898*** (0.0230)	0.1038*** (0.0191)
Age²	-0.0021*** (0.0005)	-0.0002*** (0.0002)	-0.0012*** (0.0002)
Nationality	0.3498** (0.1606)	0.4282*** (0.1006)	0.1239 (0.0968)
Marital status	0.0742 (0.1444)	0.0749 (0.0851)	0.0618 (0.0830)
Intermediate and secondary school	0.5609*** (0.1106)	0.3699*** (0.0714)	0.6006*** (0.0749)
High School	1.7929*** (0.1606)	1.2706*** (0.1108)	1.6365*** (0.1044)
Institutional Sector-Private sector Working hours' change	-1.4465*** (0.1430) -0.2738*** (0.0978)	-1.5161*** (0.0989) -0.3933*** (0.0575)	-2.0684*** (0.1044) -0.1969*** (0.0579)
The cut off points			
Cut 1	1.4933* (0.8417)	-0.7402 (0.4715)	-0.3771 (0.4097)
Cut 2	3.5749*** 0.8892	1.5471*** (0.4886)	2.0081*** (0.4276)
Cut 3	4.9824*** (0.9087)	2.7303*** (0.4965)	3.4149*** (0.4327)
Nb. Obs.	585	1546	1754
Log pseudolikelihood	-479.8136	-1290.3813	-1354.2831
Wald χ^2 (p. value)	410.40 0.0000	1078.59 0.0000	1236.03 0.0000
Percentage-cases correctly predicted Pseudo R^2	67.4% 0.3269	66.5% 0.3076	71.3% 0.3701

Notes: Robust standard-errors are reported into brackets. Levels of statistical significance: ***p < 0.001, **p < 0.05, *p < 0.1.

Source: Authors' calculations based on Labour Force Survey Q2-2020 published by General Authority for Statistics-Saudi Arabia (2020).

5. Conclusion, Recommandations and Limitations

The paper theoretical findings show that once the health stock is affected, the consumption of health goods increases especially for medicines and hospital visits despite the drop in consumer resources. Whereas the empirical findings reveal that Gender, Age, High School, Institutional Sector-Private sector and Working hours' change are statistically significant in both models (1) and (2).

The results point out a positive association between Gender, Age, High School with high and middle-income levels. The variation brought out the resilience of men and people with a higher degree of schooling in facing COVID-19. Quite the contrary, the pandemic plays a role of positive externality for them.

The COVID-19 pandemic is having a negative effect on working hours and earnings. The present crisis and the economic slowdown due to health procedures led to an increase in the absence

frequency of workers or in a reduction of working hours (1) workers lose their job; (2) workers remain employed, but they enter temporary layoffs; (3) workers remain employed, but they work only a fraction of their usual hours.

The comparison of regional impact record that Gender, Age, Nationality, Intermediate and High School, have a positive association with income distribution during the COVID-19. However, the private sector and working hours' change are negatively connected. The effect of the pandemic is more severe for foreign workers and private sector mainly in Riyadh, Southern and Western regions.

Covid-19 can have a inequal impact on some portions of the population, as witnessed during the global financial crisis, such as vulnerable people or who are already facing higher rates of unemployment and underemployment. Therefore, pro-active policies, large-scale and integrated measures are required to make strong and sustained impacts. Careful supervising of the direct and indirect pandemic effects is crucial to ensure that government policy responses are appropriate.

In fact, since the onset of the pandemic in KSA, the government has announced numerous packages targeting the private sector such as exemptions and rescheduling of some government dues, financially support the banking and SME sectors, paying the government dues to the private sector in a timely manner, providing a monthly wage subsidy of 60% in the private sector. In addition, Saudi Central Bank (SAMA) injected $13.3 billion into the banking sector to enhance liquidity to support the private sector.

The covid 19 crisis had a severe impact on low income and/or daily workers in Saudi Arabia. In fact, the application of the online work procedure seems to be not adequate to them. Even with the intervention of the government to support the private sector, the economic stagnation led some employers to reduce or suspend the payment of wages which led to difficulties to cover expenses such as rent, food…

The government should develop mechanisms to spread social protection to low-income workers such as employment guarantee schemes or governmental finance during the crisis for this type of workers especially for women.

However, this article finding discussed labor market challenges during the COVID-19 pandemic and does not at all discuss the problem of employment during normal periods.

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Appendix:

Table 4: Correlation matrix

	Income	Gender	Age	Age²	Nationality	Marital status	Intermediate School	High School	Institutional Sector	Working hours' change
Income	1	0.3824*	0.103*	0.0136*	-0.0217*	0.2795*	-0.1034*	0.3528*	0.2098*	-0.1208*
Gender		1	0.0434*	0.0367*	-0.1899*	0.0136*	0.1222*	-0.0606*	0.3667*	-0.0249*
Age			1	0.9730*	-0.0378*	0.5107*	-0.3686*	0.0061*	0.0740*	0.0700*
Age²				1	0.0095*	0.3926*	-0.3397*	-0.0447*	0.0189*	0.0786*
Nationality					1	-0.1633*	0.0262*	0.0733*	-0.5395*	-0.0234*
Marital status						1	-0.2322*	0.1496*	0.1432*	0.0015*
Intermediate school							1	-0.5916*	-0.0002*	-0.0466*
High School								1	-0.0600*	0.0612*
Institutional Sector									1	0.1363*
Working hours' change										1

Source: Authors' calculations based on Labour Force Survey Q2-2020 published by General Authority for Statistics-Saudi Arabia (2020). * 5% critical value.

Table 7: Marginal effects - Models 1 to 5

	MODEL 1 (Q2-2019)			MODEL 2 (Q2-2020)			MODEL 3 (Q2-2020)			MODEL 4 (Q2-2020)			MODEL 5 (Q2-2020)		
	Before COVID-19			During COVID-19			Capital Riyadh			North and East region			Southern and Western region		
	Low income	Middle income	High income	Low income	Middle income	High income	Low income	Middle income	High income	Low income	Middle income	High income	Low income	Middle income	High income
Gender	**-0.122** (0.019)	**0.087** (0.015)	**0.046** (0.006)	**-0.187** (0.019)	**0.113** (0.014)	**0.091** (0.008)	**-0.262** (0.497)	**0.095** (0.031)	**0.183** (0.028)	**-0.152** (0.030)	**0.087** (0.021)	**0.078** (0.014)	**-0.201** (0.030)	**0.147** (0.026)	**0.072** (0.009)
Age	**-0.053** (0.004)	**0.034** (0.003)	**0.022** (0.002)	**-0.038** (0.005)	**0.018** (0.002)	**0.022** (0.003)	**-0.056** (0.013)	0.007 (0.004)	**0.051** (0.012)	**-0.033** (0.008)	**0.016** (0.004)	**0.019** (0.005)	**-0.039** (0.007)	**0.024** (0.004)	**0.017** (0.003)
Age²	**0.001** (0.000)	**-0.0004** (0.000)	**-0.0002** (0.000)	**0.0004** (0.000)	**-0.0002** (0.000)	**-0.0002** (0.000)	**0.001** (0.000)	-0.001 (0.001)	**-0.001** (0.000)	**0.0004** (0.000)	**-0.0002** (0.000)	**-0.0002** (0.000)	**0.0004** (0.000)	**-0.0002** (0.001)	**-0.0001** (0.000)
Nationality	0.011 (0.025)	-0.007 (0.016)	-0.005 (0.011)	**-0.095** (0.023)	**0.048** (0.012)	**0.053** (0.013)	**-0.113** (0.052)	0.018 (0.012)	**0.099** (0.441)	**-0.157** (0.030)	**0.080** (0.019)	**0.089** (0.021)	**-0.046** (0.036)	0.029 (0.022)	0.020 (0.015)
Marital status	-0.020 (0.019)	0.013 (0.012)	0.008 (0.078)	-0.025 (0.020)	0.012 (0.010)	0.014 (0.011)	-0.024 (0.047)	0.003 (0.008)	0.021 (0.040)	-0.027 (0.031)	0.013 (0.016)	0.015 (0.017)	-0.023 (0.031)	0.014 (0.020)	0.009 (0.013)
Intermediate and secondary school	0.025 (0.016)	-0.016 (0.010)	-0.010 (0.007)	**-0.179** (0.017)	**0.098** (0.009)	**0.103** (0.010)	**-0.175** (0.033)	0.016 (0.012)	**0.165** (0.033)	**-0.137** (0.026)	**0.066** (0.013)	**0.079** (0.016)	**-0.222** (0.027)	**0.138** (0.018)	**0.097** (0.031)
High School	**-0.475** (0.017)	**0.157** (0.011)	**0.343** (0.020)	**-0.487** (0.017)	**0.098** (0.011)	**0.415** (0.021)	**-0.481** (0.035)	-0.0261 (0.030)	**0.534** (0.045)	**-0.429** (0.031)	**0.104** (0.014)	**0.347** (0.035)	**-0.525** (0.026)	**0.155** (0.018)	**0.393** (0.031)
Institutional sector--Private sector	**0.624** (0.014)	**-0.186** (0.013)	**-0.493** (0.203)	**0.536** (0.015)	**-0.148** (0.011)	**-0.427** (0.017)	**0.389** (0.034)	**0.050** (0.026)	**-0.455** (0.046)	**0.500** (0.025)	**-0.152** (0.016)	**-0.385** (0.026)	**0.628** (0.021)	**-0.228** (0.019)	**-0.450** (0.025)
Working hours' change	-	-	-	**0.104** (0.138)	**-0.0469** (0.006)	**-0.063** (0.008)	**0.084** (0.029)	-0.004 (0.006)	**-0.082** (0.030)	**0.145** (0.021)	**-0.063** (0.009)	**-0.090** (0.014)	**0.074** (0.021)	**-0.044** (0.012)	**-0.033** (0.010)

Notes: Marginal effects account for the change in explanatory variables on the change in the probability of outcomes in Probit models-for an infinitesimal or discrete change (respectively) in each continuous or dichotomous independent variable: Low income/Middle income and High income. Bold characters denote the fact that the coefficient associated to the variable is statistically significant at least at 10%. Robust standard-errors are reported into brackets. Levels of statistical significance: ***p < 0.001, **p < 0.05, *p < 0.1.

Source: Authors' calculations based on Labour Force Survey Q2-2019 and Q2-2020 published by General Authority for Statistics-Saudi Arabia (2019 & 2020)