IRANIAN ECONOMIC REVIEW
Print ISSN: 1026-6542
Online ISSN: 2588-6096
https://ier.ut.ac.ir/
University of Tehran

# Analysis of the Effect of Health Disaster Risk Shocks on Macroeconomic Variables: An Application of Dynamic Stochastic General Equilibrium Models

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## Article Info

**Article Type:** Research Article

**Article History:**
Received: 10 April 2021
Received in revised form: 24 August 2021
Accepted: 19 September 2021
Published online: 01 October 2023

**Keywords:**
*Economic Development, Health Shocks, Health Expenditure, Macroeconomic Variables, Quarantine Hours.*

**JEL Classification:**
*E32, I10, I15, O10.*

## ABSTRACT

The outbreak of COVID-19 has led to widespread use of mathematical models of epidemiology. These models have a fundamental defect, because they do not consider the interaction between economic decisions and rates of infection. Therefore, the main motivation of the present study is to understand the severity of the effect of health shock on Iran's oil economy using a Dynamic Stochastic General Equilibrium model. After calibrating the parameters based on the quarterly information of Iran's economy during the period of 1991-2017, the adjusted model has been simulated in three scenarios, based on the persistence of health disaster risk and the deterioration of health capital due to the disease outbreak. The results show that the occurrence of a health disaster risk shock by a standard deviation caused severe fluctuations in macroeconomic and health variables. On the other hand, with the reduction of production and health status, the development path of Iran's economy has been challenged. According to the research findings, it is recommended that the government, as a policy-maker, play a stabilizing role under pandemic crises conditions.

**Cite this article:** Keshavarzi, A., Horry, H. R., & Jalaee, S. A. (2023). Analysis of the Effect of Health Disaster Risk Shocks on Macroeconomic Variables: An Application of Dynamic Stochastic General Equilibrium Models. *Iranian Economic Review, 27*(3), 765-788. DOI: https://doi.org/10.22059/ier.2021.83922

 **Publisher:** University of Tehran Press.
DOI: https://doi.org/10.22059/ier.2021.83922

## 1. Introduction

The world has seen different economic crises since the Great Depression (1929-1939) until today. The economic policies used to overcome the crises have varied according to the time period and the depth of depression caused by the crisis, the reasons for the crisis and the extent of the crisis in different countries**.** But the Corona pandemic[1] crisis is a new chapter in the history of economic crises; To the extent that the World Health Organization (WHO) has designated it as an unprecedented global disease (Yang et al., 2020).

COVID-19 directly affects the supply side of the economy, and this is what distinguishes it from other economic crises. In other words, the coronavirus pandemic disrupted supply and supply chain systems (Fornaro and Wolf, 2020); It also led to a lack of demand (depression); This amplified the supply shock (Guerrieri et al., 2020).

The high-velocity outbreak of COVID-19 has forced governments to respond to control and manage the crisis**.** Under these conditions, most governments have taken measures such as social distancing, quarantine, closure of schools and educational centers, business, etc., which have had detrimental consequences for the economies of countries (Wang and Zhang, 2021).

In June 2020, the World Bank predicted that in the short term, global GDP would decline by 5.2 percent in 2020, and in the long run, this deep recession caused by the Corona pandemic would have a lasting effect on the global economy. Its prospects showed that advanced economies would shrink by 7 percent and transition and developing economies by 2.5 percent. These depressions are expected to reverse years of progress toward development goals (WorldBank, 2020).

In Iran, the first confirmed case of Coronavirus disease was reported on February 19, 2020 in Qom. With the increase in COVID-19 expenditures and the sharp decline in oil revenues, the ratio of the

1. According to the World Health Organization, an epidemic is a widespread but regional outbreak of a disease; but a pandemic is the worldwide spread of a new disease affecting many people.

government budget deficit to Iran's GDP increased to an unprecedented rate; From April to December 2020, only 14 percent of anticipated oil revenues were realized, due to lower oil export volumes and prices. On the other hand, with the decrease in foreign exchange supply and increasing economic uncertainty, the value of the Iranian rial decreased in 2020-21 and inflation resurged to over 48 percent (YOY) in February 2021 (WorldBank, 2021). The International Monetary Fund estimates real GDP growth rate at 1.5 percent, inflation rate at 36.5 percent and unemployment rate at 10.8 percent for Iran in 2020 (IMF, 2020). Figures 1 and 2 show comparison of real GDP growth rate and inflation rate for Iran's economy, emerging market and developing economies and advanced economies:

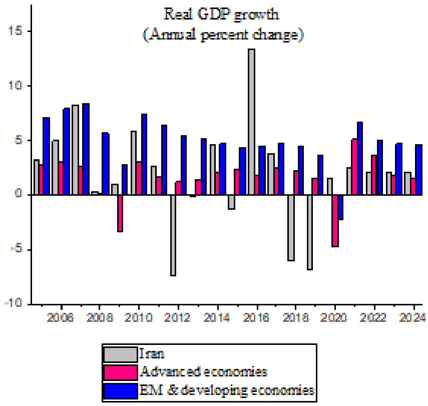



**Figure 1.** Comparison of Iran's GDP Growth with Advanced and Developing Countries
**Source:** International Monetary Fund, 2021.

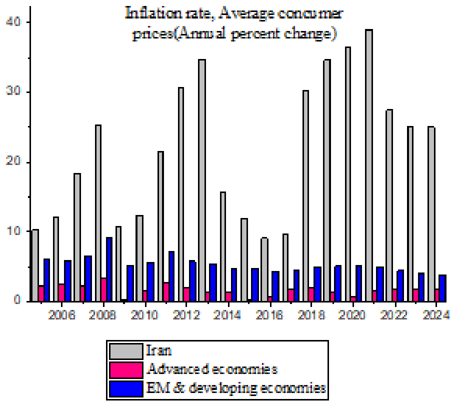



**Figure 2.** Comparison of Iran's Inflation Rate with Advanced and Developing Countries
**Source:** International Monetary Fund, 2021.

In response to this crisis, the Iranian government has pursued fiscal policies to support people’s livelihoods and health: Support for the unemployment insurance fund, Excess funding for the sector of health, and Cash subsidies to vulnerable households (IMF, 2021).

The above implications indicate the need to analyze the effects of a pandemic infectious disease on the Iranian economy. Therefore, the present study investigates the economic dimensions of the occurrence of a negative health shock as much as possible. For this purpose, according to the features of dynamic stochastic general equilibrium (DSGE) models in analyzing the effects of different shocks as well as fluctuations of economic variables, a DSGE model based on real business cycles is used. These models, developed following the critique of Lucas, follow the principles of microeconomics and can optimally evaluate the performance of economy within a stochastic environment (Lucas, 1976).

To achieve the objective, the paper is structured as follows. After introduction, section 2 presents the literature on the effect of health status as a human capital on economic variables. In Section 3, first the theoretical foundations of micro- and macroeconomic effects of pandemic outbreaks and then a DSGE model tailored to the pandemic outbreak conditions for the Iranian economy are identified. Section 4 determines the input values of the model and Section 5 analyzing the research results and examines the response functions resulting from the simulation. Finally, the study concludes with the conclusion and suggestions.

## 2. Literature Review

Grossman (1999), using human capital theory, showed that increasing the knowledge or human capital of individuals increases their productivity in the economy's market sector (generates income) and produces goods in the non-market or household sectors which enter the household's utility function. Grossman developed a model in which, the disease disturbs the activity of the labor force and work time will be wasted equivalent to the time period of regaining health.

Finkelstein et al. (2013), believes that the main effect of the disease outbreak is via reduced labor supply and increased health spending that both can reduce lifetime budget constraints and reduce consumption. On the other hand, reduced health may reduce the marginal utility of consumption.

Karlsson et al. (2014), analyzed the effect of the 1918 Spanish flu epidemic on economic performance in Sweden. To estimate the effect of the pandemic on income, return on capital and poverty, they used seemingly exogenous variation in incidence rates between Swedish regions. Also, they used the difference-in-differences model. The results show that the pandemic led to a sharp increase in poverty rates. The epidemic also had a negative impact on capital returns. But the pandemic had no significant effect on income.

Yagihashi and Du (2015), motivated by the study of the role of health expenditures in the cyclical movement, designed a general equilibrium model in which the demand for health care was distinguished from the demand for other goods. In other words, using this model, they generated inflation dynamics and cyclical health behavior that match the US data. The results show that an expansionary monetary policy shock has increased the product of equilibrium, but inflation in the healthcare sector is rising much less than in other sectors, and this was in line with empirical findings.

Vasilev (2017) examined real business cycles and their impact on labor productivity in the US economy by incorporating health status into the household utility function. To this end, the partial-equilibrium framework of Grossman (1999) with endogenous health status was considered in a standard RBC model. The results showed that health status cannot be accounted responsible for creating business cycles.

Yang et al. (2020) investigated the effects of coronavirus on tourism sector of China using dynamic stochastic general equilibrium modeling (DSGE). In this study, household utility is considered a function of lifetime consumption and health status. As the coronavirus outbreak prevents the consumption of tourism goods and services and reduces health status, welfare is also decreased. Therefore, one of the possible policies to improve the post-crisis tourism status is subsidies for the consumption of tourism goods and services.

Asoyan et al. (2020) developed a New Keynesian DSGE model for a closed economy to model the impact of health shocks on the Armenian economy. The result revealed that the decision of people to deduct working hours and consumption following the health crisis reduced the outbreak of the COVID-19 but led to an economic recession. Moreover, the expansionary monetary policy diminishes the rate of decline in GDP.

Imai et al. (2021) studied the factors affecting the severity of COVID-19 in India. The main objective of this study is to identify the socioeconomic, meteorological, and geographical factors associated with the severity of COVID-19 pandemic in India. Drawing upon random-effects models and Tobit models for the weekly and monthly panel data sets of 32 states/union territories, they have found that the factors associated with the COVID-19 severity include income, gender, multi-morbidity, urbanization, lockdown, and unlock phases, weather including temperature and rainfall, and the retail price of wheat.

In order to avoid explaining literature on the subject, a summary of other studies is depicted in Table 1:

**Table 1.** Summary and Classification of Studies

| **Author and Year** | **Model** | **Research Area** | **Purposes and Results** |
|---|---|---|---|
| McKibbin and Fernando (2020) | Combined model DSGE/CGE | Global economy | **Purpose:** To determine the potential economic costs of the coronavirus. **Results:** The coronavirus outbreak can have a significant impact on the global economy in the short term. The possible response of central banks is to reduce interest rates, but this shock is not only on the demand side, but also a multifaceted crisis that needs monetary, fiscal and health policies. |
| Guerrieri et al. (2020) | Keynesian supply shocks | USA | **Purpose:** To examine Keynesian supply shocks that lead to larger changes in aggregate demand. **Results:** Incomplete markets meet the demands for Keynesian supply shocks. Permanent layoffs and job losses can enhance the initial effects of supply shocks and exacerbate the economic depression. |
| Eichenbaum et al. (2020) | SIR-Macro model | USA | **Purpose:** To analyze the relationship between economic decisions and epidemics. **Results:** The people decision to reduce consumption leads to a reduction in the severity of the epidemic. But the decision exacerbates the depression caused by the epidemic. |
| Berger et al. (2020) | SEIR model | USA | **Purpose:** To examine the role of testing and quarantine policy. **Results:** More testing and targeted quarantine policies reduce the economic impact of the corona epidemic. |
| Faria-e-Castro (2020) | DSGE model | USA | **Purpose:** Implications for the Corona virus outbreak in the United States and appropriate fiscal policies to respond to it. **Results:** If the goal is to stabilize unemployment in the affected sector, cash benefits have the highest impact. |

**Source:** Research finding.

Some facts revealed in the framework of business cycle models suggest that exogenous changes in national account variables can be a factor of instability in the economy. Gordon et al. (2009) believe that the consumption shock of 1955 led to a boom in investment and a peak cycle in the United States. Blanchard (1993) also blames the negative consumption shock for the recession of 1990-91. Therefore, consumption behavior can contain valuable information in interpreting the original behavior in future periods. In most studies in this field, investment, employment and productivity behave as variables that agree with the cycles. Revealed facts for the Iranian economy indicate that the variables of consumption, investment and employment are procyclical with business cycles (Hooshmand et al., 2008).

Evidence and results of studies indicate the profound effects of pandemics such as the COVID-19 disease on the economies of countries. This has led to the expansion of the use of mathematical models of epidemiology. But the main drawback of these models is the lack of attention to the interaction between economic decisions and prevalence (Eichenbaum et al., 2020). For this reason, the present study investigates the effects of health disaster risk shocks in the framework of a stochastic dynamic general equilibrium model. Dynamic Stochastic General Equilibrium models can show the precise interactions between market decision-makers in the context of general equilibrium.

## 3. Model Setup

### 3.1 Theoretical Foundations

Epidemic diseases prevent patients and their caregivers from working or work less. This can reduce productivity. In other words, at the micro level, the level of activity of each person depends on his health status. Therefore, it affects the health status, quantity and productivity of labor supplied in the economy and ultimately the amount of accumulation of human capital is also influenced (Bloom et al., 2004). At the macro level, the World Health Organization (WHO, 2009), by using the flow of income in Figure 3, has shown how microeconomic factors interact and then using it, the main mechanisms of effect transfer have analyzed the outbreak of the disease as leakages on households, businesses and the government:

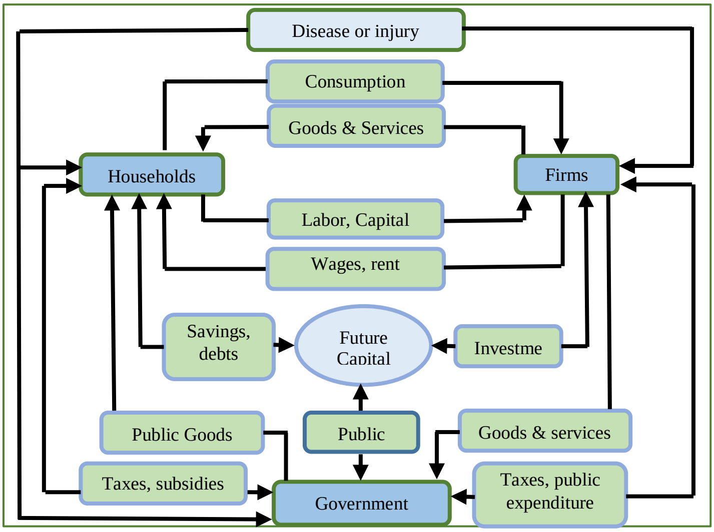



**Figure 3.** Conceptual Framework to Identify the Impact of Disease on Macroeconomics
**Source:** World Health Organization (2009).

Households provide the labor and capital required by businesses, and on the other hand, firms allocate their income in the form of wages and interest to households. Households expend part of this income and invest part of it for more consumption in the future. Although part of the labor force needed by the public sector is provided by the household, it is just a basic framework for the simple flow of income to show how economic factors interact with each other. Through direct and indirect taxes, households finance the government activities. Also, part of the disposable income of households enters the financial markets as savings, and firms use these savings to finance their activities. Illness and injury may challenge the economic capabilities of households to the extent that they are forced to use loan and debt. In other words, one of the consequences of this leakage is the reduction of the effective household labor force and their income. If this leakage is not accompanied by increasing the supply of public goods, increasing private liability, etc., it will cause a sharp drop in Gross Domestic Product (GDP). On the other hand, labor supply reduction has a negative effect on the operational activities of firms. This reduces the supply of firms and ultimately reduces aggregate demand.

Therefore, diseases can influence most of household economic decisions (Guiso et al., 2002).

### 3.2 Description of the Model

The primary element of the present study is based on the combination of models Yang et al. (2020), Asoyan et al. (2020) and by expanding these models, the impact of a pandemic infectious disease on macroeconomic variables in Iran has been investigated. In this regard, the studied economy includes households with unlimited planning horizons, final goods enterprise, and a set of heterogeneous intermediate goods companies in the monopolistic competition environment, government and oil sector.

Each household has its own capital and labor force that supplies them to the firm. Time is spent on work, activities that lead to improved health status (such as quarantine and sports, etc.) and leisure. Households acquire utility from health, but they must invest in it (health), as the health capital is depreciated over time. Households acquire utility of health, however they must invest in it (health), because health capital is depreciated in a lifetime. The firm produces goods using labor and capital under fully-competitive conditions. The government uses tax revenues from labor and capital, and oil revenues to finance its expenditures.

#### 3.2.1 Household's Problem

The purpose of the sample household is to maximize the discounted total utilities of the planning horizon (expected discounted utility) of its lifetime. In the present study, household preferences in this utility function include a sequence of consumption, leisure, and health status, and accordingly, each household follows the maximization of the expected utility of its lifetime:

$$E_0 \sum_{t=0}^{\infty} \beta^t \{lnC_t + \psi lnL_t + vlnH_t\}, \quad (1)$$

Where $E_0$displays the expected value of the operator and $H_t$shows the stock of good health. Besides, $C_t$ and $L_t$ represent the consumption and leisure in period t, respectively. Also, $0 < \beta < 1$ is discount factor of utility function, $\upsilon > 0$ executes health importance in utility function and $\psi > 0$, is weight of leisure in utility function.

The household allocates each period of time (t) to work $N_t$, quarantine hours $Q_t$ and leisure $L_t$, which time is normalized to 1 in Equation 2.

$$N_t + Q_t + L_t = 1 \tag{2}$$

The amount of wages received by each household per working hour is $W$, and as a result, acquires the income of $W_t N_t$.

Health is depreciated over time at a rate of $\delta^h$, and $I_t^h$ investment should be made to maintain health. The law of motion for health is introduced as follows:

$$H_{t+1} = \left[I_t^h + (1 - \delta^h)H_t\right] - Z_t \, .\omega \tag{3}$$

where $Z_t$ is the health disaster risk and a first-order autoregressive process. $\omega$ is the deterioration rate of health capital due to disease outbreak or size of the crisis, and $I_t^h$ is an investment in health and is a function of health expenditures ($X_t$)and dedicating quarantine hours ($Q_t$):

$$I_t^h = (X_t)^{\phi}(Q_t)^{1-\phi} \tag{4}$$

where $0 < \phi < 1$ and $1 - \phi$ are the elasticity of health investment regarding health expenditures and quarantine hours, respectively.

Finally, each household invests in physical capital and, as an owner of the capital, receives interest income $R_t.K_t$ by renting the capital to the firm. Where $R_t$ depicts the return on capital and $K_t$ performs the capital stock of period t. Moreover, households own businesses and receive profit ($\Pi_t$) in the form of dividends. The physical capital of the household develops according to the law of motion:

$$K_{t+1} = I_t^k + (1 - \delta^k)K_t \tag{5}$$

where $\delta^k$ is the depreciation rate of physical capital. Each household faces the following budget constraints:

$$C_t + X_t + K_{t+1} \leq W_t.N_t + R_t.K_t + (1 - \delta^k)K_t + \Pi_t \tag{6}$$

Maximizing the utility function (1) with respect to the budget constraint (6) and equation (3) will lead to household optimization conditions (first-order conditions):

$C_t$: $\lambda_t = \left( {}^{1}/_{C_t} \right)$ (7)

$K_{t+1}$: $\lambda_t = \beta E_t \lambda_{t+1}[(1- \tau^k)\, R_{t+1} + 1 - \delta^k]$ (8)

$N_t$: $\lambda_t W_t = \left( {}^{\psi}/_{1 - N_t - Q_t} \right)$ (9)

$Q_t$: $\left( {}^{\psi}/_{1 - N_t - Q_t} \right) = \mu_t \left( X_t^{\phi} \right) (1 - \phi) W_t (W_t Q_t)^{-\phi}$ (10)

$H_{t+1}$: $\mu_t = \beta \left\{ \frac{v}{H_{t+1}} + \left(1- \delta^h\right). \mu_{t+1} \right\}$ (11)

$X_t$: $\lambda_t = \mu_t (\phi)(X_t)^{\phi-1}(W_t Q_t)^{1-\phi}$ (12)

$\lim_{n\to\infty} \beta^t \lambda_t K_{t+1} = 0$ (13)

$\lim_{n\to\infty} \beta^t \mu_t S_{t+1} = 0$ (14)

where $\lambda_t$ the Lagrangian multiplier is related to the household budget constraint and $\mu_t$is the Lagrangian coefficient of the capital motion. The first equation in the first-order condition is derived from the optimality of the marginal utility of consumption with the shadow price of wealth. The second equation is the Euler equation, which shows the optimal allocation of physical capital in two consecutive periods. The working hours are then chosen in such a way that the final cost of the work is equal to the final cost of the work. Quarantine hours are determined in such a way that the health benefits of an extra hour of quarantine are offset by the cost of utility. The next optimal condition is the inter-tempora allocation of health; where the household equates the ultimate benefit with the ultimate cost of good health. Health expenditures are determined in such a way that the health income from an additional unit of health expenditures is offset by the utility cost.

### 3.2.2 Firms

The firm produces a homogeneous final product using Cobb Douglas's production function that requires physical capital and labor:

$Y_t = A_t K_t^{\alpha} (N_t)^{1-\alpha}$ (15)

Where $A_t$ indicates the level of technology (Hicks neutral) available to the economy in period t.

$0 < \alpha, (1 - \alpha) < 1$ is the productivity of capital and labor.

In each period, the firm pursues maximizing profits:

$$\Pi_t = A_t K_t^{\alpha} (N_t)^{1-\alpha} - R_t . K_t - W_t . N_t \tag{16}$$

In equilibrium (long-term), firms' profits are zero, and each factor of production will receive as much revenue as its final output:

$$W_t = (1-\alpha)\frac{Y_t}{N_t} \tag{17}$$

$$R_t = \alpha \frac{Y_t}{K_t} \tag{18}$$

### 3.2.3 Government

The government consumes an exogenous amount of resources in each period. Government expenditures are financed by oil revenues and taxes. Therefore, the dynamic government budget constraint is as follows:

$$G_t = O_t + T_t \tag{19}$$

where $G_t$, $O_t$, $T_t$ indicate government expenditures, oil revenues, and per household lump-sum taxes, respectively.

Oil revenues in most oil-exporting countries account for a large proportion of the government budget. This equation states that capital and labor are the two main sources of financing through the tax channel.

### 3.2.4 Oil

There are several ways to integrate the oil sector with the model. In some studies, this sector is considered such as the enterprise sector and pursued the goal of maximizing profits for the oil sector. In some other studies, an exogenous process has been used to model this section. In the present study, the purpose of this section is to maximize revenue. As the National Iranian Oil Company, as the reference for oil sales, does not pursue maximization of profit, like most state-owned companies (Sayadi and Khosroshahi, 2020).

Since oil revenues are injected into the economy in oil-rich countries, and changes in exchange rates besides oil prices, may be effective in reducing or increasing oil revenues, it seems Oil revenue shocks should be more appropriate for oil-exporting countries than oil price shocks. The change in oil revenues can be due to a change in the amount of oil exports $EXP_t^{oil}$or a change in the price of oil $P_t^{oil}$ or a change in the exchange rate $e_t$, or a combination of them, which in the present study, these shocks are gathered into stochastic shocks of oil revenues $\varepsilon_t^{Roil}$.

$$O_t = e_t.EXP_t^{oil}.P_t^{oil} \quad (20)$$

In fact, a completely separate model can be designed for each of these variables, but based on the purpose of the present study, the shocks introduced in this section are included in the oil revenue shock.

### 3.2.5 General Constraint of Resources

In terms of the market settlement, aggregate supply and aggregate demand are equal:

$$Y_t + O_t = C_t + X_t + I_t^k + G_t = GDP_t \quad (21)$$

Accordingly, the total production of non-oil final goods and oil revenues, which are spent on imports of final goods, allocated to final consumption and health expenditures of household, private sector investment in production, and government expenditures. Consequently, the final goods market can be balanced.

### 3.2.6 Exogenous Stochastic Processes

The existing stochastic variables in the designed model include the total factor productivity $A_t$, and the health disaster risk $Z_t$, and $R_t^{oil}$oil revenues, which follow a first-order autoregressive process. Autoregressive process of the total factor productivity is:

$$\ln\left(\frac{A_t}{\bar{A}}\right) = \rho_A \ln\left(\frac{A_{t-1}}{\bar{A}}\right) + \varepsilon_t^A, \qquad \varepsilon_t^A \sim N(0, \sigma_a^2) \quad (22)$$

where $\bar{A} > 0$ is steady state level of the total factor productivity process, $0 < \rho_a < 1$ is the first-order autoregressive persistence parameter and $\varepsilon_t^a$ are random shocks to the total factor productivity process.

The first-order autoregressive process of health disaster risk is:

$$\ln(\frac{Z_t}{\bar{Z}}) = \rho_z \ln(\frac{Z_{t-1}}{\bar{Z}}) + \varepsilon_t^z, \qquad \varepsilon_t^z \sim N(0, \sigma_z^2) \quad (23)$$

where $\bar{Z}$>0 is the steady-state level of the health disaster risk process, $0 < \rho_Z < 1$ is the persistence parameter of AR(1) and $\varepsilon_t^z$are random shocks to the health disaster risk process.

The first-order autoregressive process of oil revenues is:

$$ln\left(\frac{O_t}{\bar{O}}\right) = \rho_O ln\left(\frac{O_{t-1}}{\bar{O}}\right) + \varepsilon_t^O, \qquad \varepsilon_t^{R^O} \sim N(0, \sigma_O^2) \quad (24)$$

where $O_t$ is the oil revenue of period t and $\bar{O}$ is the real revenue from the sale of oil in steady-state, $0 < \rho_O < 1$ is the persistence parameter of AR(1), and $\varepsilon_t^O$ are random shocks to the oil revenue process.

## 4. Validation of Model Parameters

The model set in the previous stage is calibrated with a quarterly frequency (quarterly), and in accordance with the data of Iran's economy (1991:1-2017:4). Quarterly data on real production, household consumption, private sector investment, interest rates were extracted from the Central Bank of Iran (CBI, 2020). Quarterly data on health status and household health expending have been obtained from the World Health Organization (WHO, 2020). The ratio of model variables of steady state is presented in Table 2:

**Table 2.** Long-term Values of Variables Relative to Non-Oil Production

| Rate | Explanation | Value |
|---|---|---|
| $C/_{GDP}$ | Stable ratio of private consumption to gross domestic product | 0.62 |
| $I^k/_{GDP}$ | Stable ratio of private investment to gross domestic product | 0.15 |
| $G/_{GDP}$ | Stable ratio of government spending to gross domestic product | 0.19 |

**Source:** Research finding.

As it is not possible to calculate the steady state of some model variables (such as quarantine hours and health status, etc.) while the limits of some parameters are approximate (e.g. mental discount rate, physical capital depreciation rate, labor share and Capital of production, etc.), the value of the steady state of some variables such as quarantine hours, is considered unknown and the value of parameters such as mental discount factor is adjusted so that the results of solving the stationary nonlinear equations are mostly consistent with the real statistics.

The discount factor $\beta = 0.964$ was calibrated by the household Euler equation. The weight of health in the utility function of $\upsilon = 0.17$ is derived from dividing the share of health spending in the household consumption basket (0.05) by the share of the household's non-durable consumption spending from production (0.33). The share of the labor force in total income was obtained as $1 - \alpha = 0.588$ through the average share of the total wage bill in GDP. The capital depreciation rate is set to $\delta^k = 0.028$, which is a normal value for the Iranian economy. Health capital depreciation rate $\delta^h = 0.08$ has been extracted and has made the model more flexible.

The value of quarantine hours in the health production function was calculated to be $Q_t = 0.04$. The elasticity of investment in health relative to health expenditures is estimated to be $\phi = 0.27$.

A is the steady state levels for total factor productivity, normalized to 1. The shock process parameter A is estimated from an AR (1) regression. Therefore, after estimating the solo residual, the coefficient of persistence $\rho_A = 0.8$ and the standard deviation of $\sigma_A = 0.01$ were obtained. In the baseline calibration, we identify a monthly disaster probability of 0.075%, implying that disaster occurs every 30 years on average (Barro & Ursua, 2008). Similarly, for the process parameters of $Z$ and $O$ shocks, the coefficients of persistence are obtained $\rho_z = 0.6$ and $\rho_O = 0.798$ and the standard deviation of $\sigma_Z = 0.01$ and $\sigma_O = 0.01$.

The scenario making in the adjusted model is based on the parameters $\rho_z$ and $\omega$, which indicates persistence of health disaster risk and the magnitude of the crisis (the deterioration rate of health capital due to the disease outbreak) in the equation of motion of health capital and are 0.6 and 0.1 in the basic scenario. Also, the parameter value $\rho_z$ is considered 0.4 and 0.8 in both optimistic and pessimistic scenarios, respectively. The parameter value $\omega$ is considered 0.05 and 0.15 in both optimistic and pessimistic scenarios, respectively. The results of parameters are shown in Table 3:

**Table 3**. Calibrated Values of Model Parameters

| Parameter | Description | Value |
|---|---|---|
| $\beta$ | Discount factor | 0.964 |
| $\nu$ | Weight on utility from health | 0.17 |
| $\alpha$ | Capital productivity | 0.412 |
| $\psi$ | weight on utility from leisure | 1.58 |
| $\delta^k$ | Depreciation rate of physical capital | 0.028 |
| $\delta^h$ | Depreciation rate of health capital | 0.08 |
| $\phi$ | Productivity of health expending | 0.27 |
| $A$ | Steady-state of technology | 1.00 |
| $z$ | Steady-state of health disaster risk | 0.0075 |
| $\rho_A$ | AR(1) parameter, total factor productivity | 0.8 |
| $\rho_Z$ | AR(1) parameter, persistence of health disaster risk | 0.6 |

| Parameter | Description | Value |
|---|---|---|
| $\rho_O$ | AR(1) parameter, oil revenues | 0.798 |
| $\sigma_A$ | Standard deviation, total factor productivity | 0.01 |
| $\sigma_Z$ | Standard deviation, health disaster risk | 0.01 |
| $\sigma_O$ | Standard deviation, oil revenues | 0.01 |
| $\omega$ | size of the crisis | 0.1 |

**Source:** Research finding.

The model simulation presented in the study was performed using Dynare program that runs in the MATLAB software environment and the results were analyzed under different scenarios.

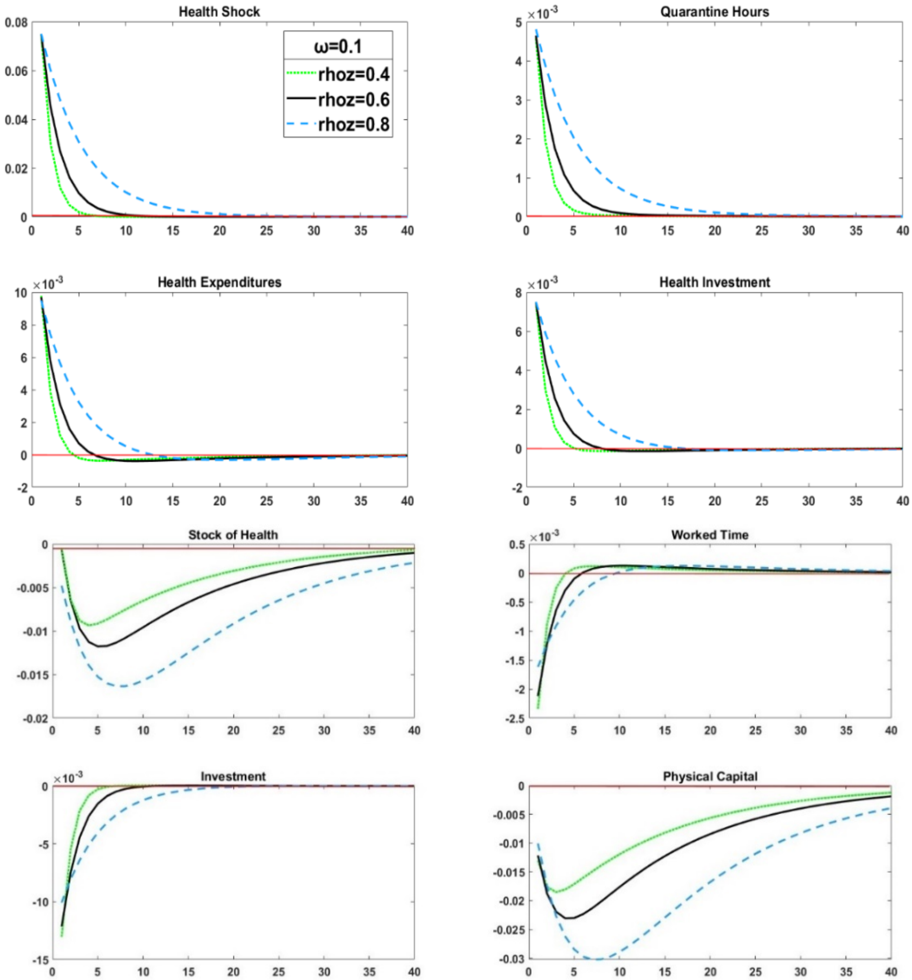
## 5. The Impact-Response Functions of Model Variables

Impulse Response Function (IRF) shows the dynamic behavior of model variables over time, when a shock occurs by a standard deviation to a variable that is affected by the shock. In this section, the IRF of macroeconomic variables in response to health shocks, productivity shocks and oil revenue shocks are investigated.

### 5.1 Impact-Response Functions against Health Disaster Risk Shock

Figure 4 shows how the risk of a health disaster would effect on macroeconomic variables, displaying the impulse response functions (IRFs) to a shock of $\omega t$ in our baseline scenario $\rho_z = 0.6$ (solid line in Figure 4). Increased risk of health disasters, by a standard deviation, leads to deterioration health status. To improve health status, health expenditures and quarantine hours have been increased, which means increased investment in health. On the other hand, because the sum of working hours, leisure hours, and quarantine hours is proportional, when more hours are devoted to quarantine, working hours are reduced and consequently the final productivity of Physical capital is reduced, which is due to the complementarity of labor and capital in the production function of Cobb Douglas. Finally, labor income and capital income must also decrease. Therefore, total production and consumption fluctuate significantly, and this is due to the optimal choice of households in the face of this shock. The investment response is very similar to the behavior of consumption, production and working hours, but its reduction is more obvious because investment costs are inherently more unstable than other types of costs. Over time, physical capital shortages increase interest rates, physical investment, and working hours, and eventually slowly return to their steady levels.

Figure 4 also shows how the economy reacts to the persistence of health disaster risk in different situations. In the optimistic scenario $\rho_z = 0.4$, the dynamics of the variables after the health shock is quite similar to the baseline scenario, with the only difference being its lesser intensity. And in the pessimistic scenario $\rho_z = 0.8$, the dynamics intensity of the variables is more intense than both scenarios.



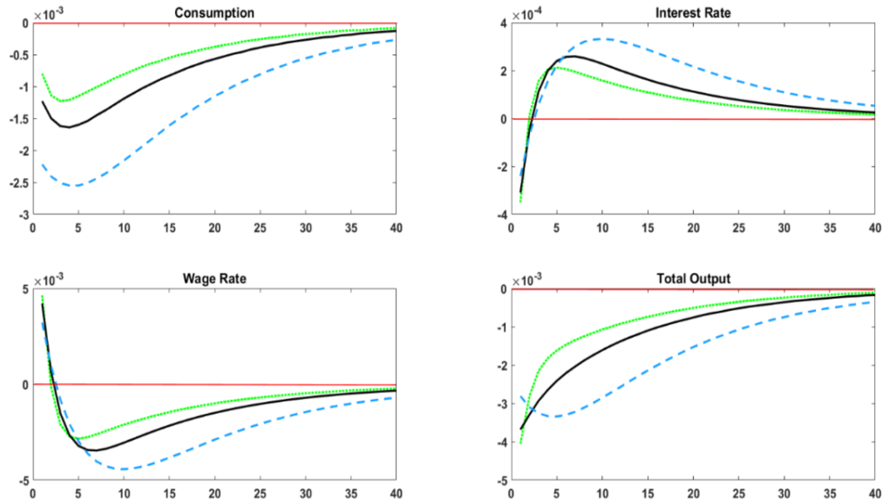
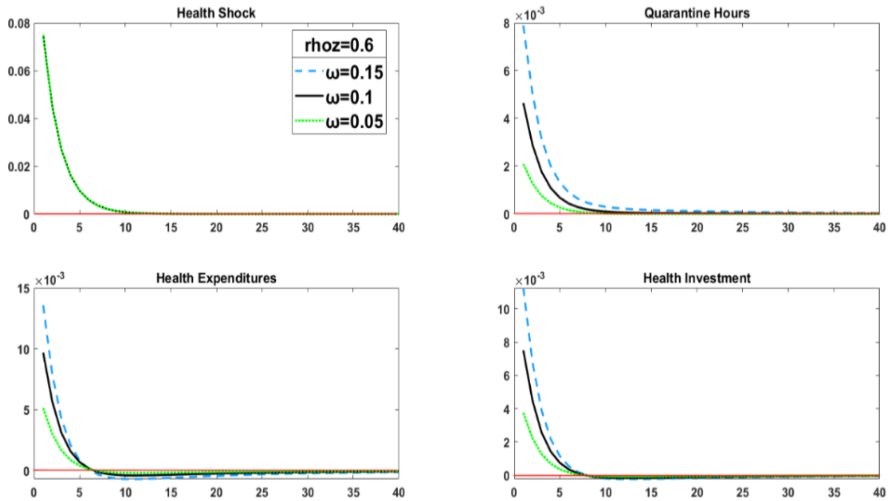



**Figure 4.** Effect of a 1% Increase in Health Disaster Risk at Different Levels of Risk Persistence

**Source:** Research finding.

These trends represent a typical path during the outbreak of a social-wide pestilence (WHO, 2018).

Figure 5 displays how the size of a disaster matters when the risk persistence is flat. In this figure, all variables experience a further decrease as the size of a disaster enhances.



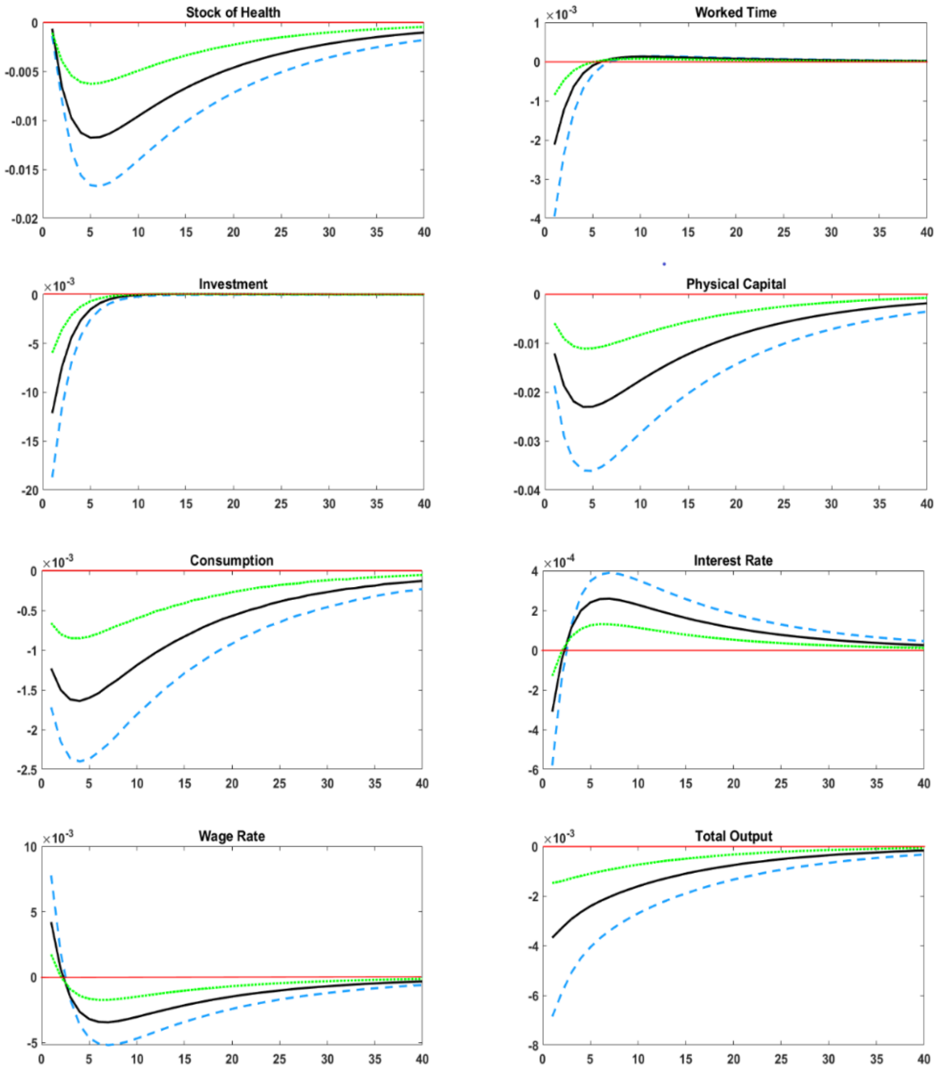



**Figure 5.** Effect of a 1% Increase in Health Disaster Risk at the Different Disaster of the Sizes

**Source:** Research finding.

## 6. Conclusion

The outbreak of coronavirus and its destructive effects on the economies of countries have led to the use of various models to simulate the effects of the epidemic. In the present study, due to the special features of dynamic stochastic general equilibrium models, a real business cycle model was used. The designed model was calibrated in three scenarios according to the persistence of health disaster risk and the size of the disaster. For this purpose, the simulated model is made in three scenarios and according to the persistence of health disaster risk and degree of deterioration of health capital resulting from the outbreak of the disease. The results indicate that the occurrence of a health shock by a standard deviation will reduce working hours and consequently reduce the final productivity of physical capital. Finally, labor income and capital income must also decrease. Therefore, production, physical investment and total consumption are significantly reduced. Also, the decrease in production and the decline in health status have led to a slowdown in the development process in Iran. Therefore, the role of the government during the outbreak of the epidemic becomes very prominent.

Overall, the Iranian economy is highly dependent on oil exports and petroleum products. Meanwhile, international sanctions have led to sharp fluctuations in macroeconomic variables in the last decade. Thus, the development path of Iran’s economy has been challenged. Under these circumstances, the outbreak of COVID-19 in Iran imposed additional health expenditures for governments and households. On the other hand, the Coronavirus pandemic has led to lower prices of oil and petroleum products. Consequently, this is the most key channel through which the economic impact of a pandemic in Iran is evident. The findings of this study are consistent with the results of the studies of Eichenbaum et al. (2020), Yang et al. (2020), Berger et al. (2020), and Asoyan et al. (2020).

As a recommendation for future studies, the role of monetary policy in managing a health crisis can be analyzed if the structure of the model changes according to New Keynesian assumptions and issues such as market incompleteness and price stickiness. Also, by expanding the role of government in the economy, the effect of government fiscal policies on fluctuations in macroeconomic variables, after encountering the pandemic outbreak, can be investigated. The effect of the prevalence of a pandemic disease under different regimens can also be evaluated according to Markov switching models.

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