Unconventional Monetary Policy Response to Covid-19 and Its Impact on Inflation in Morocco

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Received 25.2.2024 (revision received 27.4.2024), **Accepted** (reviewed) 30.4.2024, **Published** 13.9.2024

Abstract

This study explores the impact of unconventional monetary policy on Morocco's economy during the Covid-19 pandemic. We used a hybrid model combining a financial dynamic stochastic general equilibrium (DSGE) model with a standard epidemiology model, enabling us to consider both economic and epidemiological factors. Our results indicate that unconventional monetary policy cannot fully mitigate the adverse effects of a pandemic, except for an exogenous increase in Central Bank claims. We also found that Morocco's high inflation is partly due to Bank Al-Maghrib's unconventional monetary measures in response to the pandemic. Our research underscores the importance of monetary authorities balancing the benefits and risks of unconventional monetary policy. While it can stimulate the economy during crises, it should be used judiciously to avoid long-term negative effects. Incorporating epidemiological factors into macroeconomic models is crucial for understanding the intricate interplay between the economy and public health crises.

Keywords	***DOI***	***JEL code***
Monetary policy, financial DSGE, epidemiology model	*https://doi.org/10.54694/stat.2024.8*	*E1, E5, E6, H5, I1*

INTRODUCTION

The Covid-19 pandemic has wrought significant disruption across global economies, prompting fiscal authorities worldwide to devise and implement stabilization packages to support households and businesses. In response, major central banks, including the Federal Reserve and Bank Al-Maghrib (BAM), have

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rapidly deployed their Financial Crisis Toolkits. BAM, for instance, undertook several measures to bolster the economy: it reduced the key rate from 2.25% to 2% on March 17, followed by a further reduction to 1.5% on June 16, thereby easing the financing conditions for households and companies. Additionally, BAM enhanced its refinancing program for small and medium-sized enterprises (SMEs) to encompass both investment and operating credits, and banks were granted access to BAM's refinancing instruments in dirham and foreign currency. Tailored measures were also developed specifically for banks.

Prior to the pandemic, the integration of epidemiology into macroeconomic theory was sparse, with notable exceptions in microeconomics, as evidenced by the works of Horan and Wolf (2005), Horan and Fenichel (2007), Fenichel et al. (2011), Lenhart and Workman (2007), and Morin et al. (2015). More recently, researchers have employed Susceptible-Infected-Recovered (SIR) epidemiological models to assess the potential economic impacts of pandemics on a macroeconomic scale, aligning with the macro model proposed by Eichenbaum et al. (2020b). Yet, the role of financial intermediaries in epidemic-economic systems has been largely uncharted territory, and the focus on how monetary policies can alleviate the economic toll of pandemics has been limited.

Our research methodology draws inspiration from the approach of Verónica Acurio Vásconez et al. (2021), utilizing a hybrid macroeconomic and epidemiological model. We meld a dynamic stochastic general equilibrium (DSGE) model akin to Smets and Wouters (2007), which includes a financial sector as conceptualized by Gertler and Karadi (2011), with a Susceptible-Exposed-Infected-Recovered (SIR) epidemiological model. This fusion allows us to probe the efficacy of monetary policy interventions in the current crisis, culminating in a financial DSGE-SIR model.

This innovative model encompasses six distinct entities: households, financial intermediaries, non-financial goods producers, capital producers, retailers, and the government. It reflects the actions of a central bank that wields both conventional and unconventional monetary policy tools. Our study goes beyond the frameworks of Smets and Wouters (2007) and Gertler and Karadi (2011) in terms of methodology. It does this by combining the financial DSGE model with an SIR epidemiological model, rather than just assuming that the number of infected people affects the economy on both the supply and demand sides. On the demand side, we agree with Faria-e Castro's (2020) statement that the number of infected people shows how bad the disease is. This means that the marginal utility of household consumption goes down. Because people may be less willing to buy things in crowded places because they are more likely to get sick. On the supply side, the pandemic's economic ramifications could be reflected in households' labor supply decisions. We hypothesize that labor supply is contingent upon the number of healthy individuals, as determined by the SIR model, and that these dynamics result in consumption and output contractions. Furthermore, households that consume less may exhibit reduced work incentives, resulting in a curtailed labor supply. The government's role in providing unemployment benefits to those incapacitated by illness is also considered. Using the latest research from Moustabchir et al. (2023) and El Ouazzani et al. (2023), our study recognizes that "pandemic loans" from central banks and other non-traditional monetary policy measures might help lessen some of the bad effects of a pandemic crisis. Also, Moustabchir et al.'s (2024) study of the war between Russia and Ukraine and its effects on the Moroccan economy shows how important it is to take risk premium shocks into account when making economic policy, since they can cause inflation and real currency depreciation. These insights are instrumental in understanding the broader economic landscape within which our model operates, as well as the complex interplay of global events and policy responses.

We evaluate the effects of unconventional monetary policy through modeling this policy by quantitative easing, particularly in form of quantitative easing (QE) or loan policy. We model successive cuts in the policy rate as a Central Bank liquidity injection into the real sector in the form of claims that do not pass through private banks. This measure can be understood as a light form of "helicopter money" (Friedman, 1969), in the sense that the injected liquidity goes directly to the real sector without the direct involvement of fiscal authorities or private banks. According to our model's simulation results, a reduction in the policy rate can encourage household consumption, but its effect on output may be ambiguous and influenced by a variety of factors. However, if the policy is implemented for an extended period or excessively, it may result in increased inflation and excessive credit growth, which could have adverse impacts on investment and financial stability.

The next sections of the paper are organized as follows: Section 1 provides an empirical analysis of the literature that emphasizes the role of monetary policy in resolving the issues presented by the Covid-19 situation. In Section 2, we go into the basic ideas underpinning the SIR (Susceptible-Infectious-Recovered) model while also illustrating the possibility of integrating it with the financial DSGE (Dynamic Stochastic General Equilibrium) model. Additionally, Section 3 details the calibration approach applied to calculate parameters relevant to the Moroccan economy as well as provides the findings gained from numerical summations. Lastly, the study finishes with a final section summarizing the important results and implications.

1 LITERATURE REVIEW

The Covid-19 pandemic has presented unprecedented challenges to emerging market economies (EMEs), as highlighted by Carvalho et al. (2021). These authors have illuminated the difficulties faced by EMEs, including reduced capital inflows and a sharp decline in commodity prices. They observed that EMEs with more flexible exchange rate regimes and lower levels of external debt were able to respond more effectively to the crisis through a combination of monetary and fiscal policies. This study serves as a starting point for our analysis, establishing a framework for understanding the importance of macroeconomic stability and financial resilience.

Complementing this, Hasanov and Bulut (2021) analyzed the impact of the pandemic on macroeconomic variables in Turkey, concluding that the government's policy response helped stabilize the economy. Similarly, Escaith and MacGregor (2021) examined the repercussions of the pandemic on Latin American economies, revealing that countries with more flexible exchange rates and stronger policy frameworks fared better during the crisis. These studies reinforce the argument that effective monetary policy is crucial for supporting economic stability in EMEs during a pandemic.

Belke et al. (2021) explored the impact of Covid-19 on inflation dynamics and monetary policy in the euro area, finding a significant decline in inflation expectations and an increase in uncertainty about the inflation outlook. They advocate for the European Central Bank (ECB) to adopt a more flexible approach to inflation targeting, including a greater emphasis on forward guidance and more active use of unconventional policy tools such as asset purchases. This analysis is essential to our discussion as it underscores the importance of international policy coordination in facing the challenges posed by the pandemic.

The use of Dynamic Stochastic General Equilibrium (DSGE) models to analyze the impact of monetary policy during the Covid-19 pandemic has been highlighted by Bauer and Rudebusch (2021), who found that the Federal Reserve's policy response successfully stabilized inflation and output, although there might be long-term costs associated with the use of unconventional policy tools such as asset purchases. Galesi and Sgherri (2021) noted that the pandemic led to a significant decline in economic activity and inflation in the euro area and that the ECB's policy actions helped mitigate the negative effects of the crisis. Similarly, Lemoine and Lindé (2021) discovered that the pandemic led to a significant decline in economic activity and inflation in France and that the ECB's policy actions were effective in stabilizing financial markets and supporting the economy.

However, these authors also noted that the use of unconventional policy tools had an increased the risk of financial instability in the long run. Coibion et al. (2021) used a DSGE model to analyze the impact of the pandemic on the U.S. economy and found that the Federal Reserve's policy response had been effective in stabilizing inflation and output. They also noted that the use of unconventional policy tools had been necessary in a crisis of this magnitude, but that their long-term use had risks.

Our research connects two streams of literature by incorporating two popular models. Firstly, we build upon the widely used method of modeling epidemics, based on the seminal contribution of Kermack and McKendrick (1927) and its extension to include asymptomatic infected individuals (Prem et al. 2020). Secondly, we incorporate this modified SEIR model into a financial New Keynesian business cycle framework, similar to the one developed by Gertler and Karadi (2011). Our complete framework is most similar to the approach taken by Eichenbaum, Rebelo, and Trabandt (2020a), who demonstrate that a DSGE model with an SIR component can effectively capture macroeconomic processes during an epidemic.

This integration offers a unique perspective, allowing for a more precise analysis of the economic repercussions of the pandemic. It also emphasizes the need for a careful assessment of the short- and long-term costs and benefits of different policy actions. By linking these models, we provide a deeper understanding of the complex challenges faced by central banks and policymakers in responding to a crisis of such magnitude.

2 THE MODEL

2.1 Equations of SEIR model

The global health crisis of the coronavirus has led to the use of epidemiological mathematical models to make decisions on health and politics. The susceptible-infected-removed (SIR) model, which originated in the early 20th century, is a popular model in epidemiology for depicting infectious disease transmission. In this research, we use the susceptible-exposed-infected-removed-deceased (SEIR) model, an extension of the SIR model. As its name suggests, the model consists of five components:

- the number of susceptible individuals S: individuals who are healthy but can contract the disease;
- the number of exposed individuals E: persons who are infected but not yet infectious;
- The number of infected individuals I: who suffer from the disease and can spread it to susceptible individuals;
- the number of recovered individuals R: who have contracted the disease but have recovered and are immune to future infections;
- the number of deceased individuals D: who have contracted the disease but have died.

The S, E, I, and R compose the model's name (SEIR). For simplicity, we normalize the total population N to 1. Then S, E, I and R can be interpreted as shares or proportions of individuals of each class in the general population.

Furthermore, we focus only on transmitting the disease in a location or a closed economy. The standard SEIRD model assumes that no births occur and no people enter or exit the location. Hence, the population N is constant over time. For any time t, we have: $S_t + E_t + I_t + R_t + D_t = 1$ Susceptible individuals might get infected in three ways: buying consumer products, working, and having random interactions unrelated to economic activity. The transmission function reveals the frequency of newly infected individuals:

$$T_t = \pi_1(S_t C_t^s)(I_t C_t^i) + \pi_2(S_t L_t^s)(I_t L_t^i) + \pi_3 S_t I_t \,, \tag{1}$$

Let N be the total population, and let S, E, I, R, and D be the number of susceptible, exposed, infected, recovered, and deceased individuals, respectively. The rates of change of these variables over time can be described by the following system of differential equations:

$$\frac{dS}{dt} = -\beta SI \,, \tag{2}$$

$$\frac{dE}{dt} = \beta SI - \sigma E\,, \tag{3}$$

$$\frac{dI}{dt} = \sigma E - (\gamma + \mu)I\,, \tag{4}$$

$$\frac{dR}{dt} = \gamma I\,, \tag{5}$$

$$\frac{dD}{dt} = \mu I\,, \tag{6}$$

where β is the effective contact rate, σ is the rate at which exposed individuals become infectious, γ is the recovery rate, and μ is the mortality rate. This system of equations describes how the number of individuals in each compartment changes over time as the disease spreads through the population.

2.2 Households

To link the DSGE model with the SIR modeling of the Covid-19, we assume that the disease can affect the economy through both the demand and supply sides Faria-e-Castro (2020). Assume that in the economy, there are infinitely many identical households. The representative household has the following expected lifetime utility U:

$$U = E_t \sum_{t=0}^{\infty} \beta_t \left\{ Health \left(\frac{C_t^{1-\sigma}}{1-\sigma} - \frac{L_t^{1+\varphi}}{1+\varphi} \right) \right\}, \tag{7}$$

where β is a discount factor. C_t and L_t are consumption and labor supply at time t, respectively. The key difference between our model and the literature lies in the introduction of term Health is related variable that affects consumption and labor supply. With the health variable including the variables of SIR model.

$$Health_t = \{S_t, I_t, R_t\}.$$

Therefore, the utility function become:

$$U = E_t \sum_{t=0}^{\infty} \beta_t \left\{ s_t \left(\frac{C_{t,s}^{1-\sigma}}{1-\sigma} - \frac{L_{t,s}^{1+\varphi}}{1+\varphi} \right) + e_t \left(\frac{C_{t,e}^{1-\sigma}}{1-\sigma} - \frac{L_{t,e}^{1+\varphi}}{1+\varphi} \right) + i_t \left(\frac{C_{t,i}^{1-\sigma}}{1-\sigma} - \frac{L_{t,i}^{1+\varphi}}{1+\varphi} \right) + r_t \left(\frac{C_{t,r}^{1-\sigma}}{1-\sigma} - \frac{L_{t,r}^{1+\varphi}}{1+\varphi} \right) \right\}. \tag{8}$$

The representative household is subject to a budget constraint that correlates its expenditures with its resources:

$$P_t C_{H,t} + B_{t+1} \leq b_t i_t L_{t,i} + W_t (s_t L_{t,s} + r_t L_{t,r}) + R_t B_t + T_t + P_t D_t\,. \tag{9}$$

The variables $C_{H,t}$ and $L_{t,s}$, $L_{t,i}$, $L_{t,r}$ means the consumption and hours worked of susceptible, infected and recovered hoseholds, respectively.

The variables B_t, D_t, W_t, b_t and P_t mean government bond held by the household, dividends earned by the household, wages paid by firms, unemployment compensation received by infected peoples and the aggregate price level respectively.

The law of motion for the stock of capital is:

$$K_{t+1} = Inv_t + (1 - \delta)K_t \, , \tag{10}$$

The first-order conditions for $C_{t,s}$, $C_{t,e}$, $C_{t,i}$, et $C_{t,r}$ are:

$$C_{t,s}^{-\sigma} = \lambda_t^b P_t - \lambda_t^\tau \pi_1(I_t C_t^I) \, , \tag{11}$$

$$C_{t,e}^{-\sigma} = \lambda_t^b P_t \, , \tag{12}$$

$$C_{t,i}^{-\sigma} = \lambda_t^b P_t \, , \tag{13}$$

$$C_{t,r}^{-\sigma} = \lambda_t^b P_t \, , \tag{14}$$

here, λ_t^b is the Lagrange multiplier on the household budget constraint. The first-order conditions for $L_{t,s}$, $L_{t,i}$ and $L_{t,r}$ are:

$$L_{t,s}^{\varphi} = \lambda_t^b W_t + \lambda_t^\tau \pi_2(I_t N_t^i) \, , \tag{15}$$

$$L_{t,e}^{\varphi} = \lambda_t^b b_t \, , \tag{16}$$

$$L_{t,i}^{\varphi} = \lambda_t^b b_t \, , \tag{17}$$

$$L_{t,r}^{\varphi} = \lambda_t^b W_t \, .$$

The first-order condition for K_{t+1} is:

$$\lambda_t^b P_t = \beta \lambda_{t+1}^b [R_{t+1}^k + P_{t+1}(1 - \delta)] \, , \tag{18}$$

2.3 Firms and Calvo pricing

The model distinguishes between two types of firms: Intermediate Non-Financial Firms and Retailers. The first type of firm produces a range of differentiated goods, operating in an imperfectly competitive market. The second type of firm produces final goods and is characterized by a representative firm that aggregates the production of a range of intermediate firms j ∈ [0,1]. The aggregation function, based on the Dixit-Stiglitz model, is defined as:

$$Y_t = \left(\int_0^1 Y_{i,t}^{\frac{1}{\theta}} di \right)^{\theta} , \theta > 1 \, , \tag{19}$$

where θ is the elasticity of substitution between differentiated goods. This representative firm maximizes its profit according to the following equation:

$$Prof_t = P_t Y_t - \int_0^1 P_{i,t} Y_{i,t} \, di = P_t \left(\int_0^1 Y_{i,t}^{\frac{1}{\theta}} di \right)^{\theta} - \int_0^1 P_{i,t} Y_{i,t} \, di \, . \tag{20}$$

Profit maximization implies the following demand schedule for intermediate products:

$$Y_{i,t} = \left(\frac{P_{i,t}}{P_t}\right)^{-\frac{\theta}{\theta-1}} Y_t \,, \tag{21}$$

here, $P_{i,t}$ denotes the price of intermediate input i in units of the final good. The price of output is given by:

$$P_t = \left(\int_0^1 P_{i,t}^{-\frac{1}{\theta-1}} di\right)^{-(\theta-1)} . \tag{22}$$

For *Intermediate Non-Financial Firms:* The production function of intermediate good firm i is a Cobb-Douglas function given by:

$$Y_{i,t} = AK_{i,t}^{\eta} L_{i,t}^{1-\eta} \,, \tag{23}$$

where $L_{i,t}$ and $K_{i,t}$ are the labor and capital employed by firm i, respectively. A is the total factor productivity (TFP) level of the economy, which is shared by all intermediate good firms and is assumed to be constant. Intermediate good firms maximize profits:

$$\pi_{i,t} = P_{i,t} Y_{i,t} - mc_t Y_{i,t} \,. \tag{24}$$

The firm's maximization problem gives the following first-order conditions for $K_{i,t}$ and $L_{i,t}$:

$$\eta \frac{Y_t(i)}{K_t(i)} mc_t = r_{K,t} \,, \tag{25}$$

$$(1 - \eta) \frac{Y_t(i)}{L_t(i)} mc_t = w_t \,. \tag{26}$$

Calvo pricing: Nominal price rigidity is imposed using Calvo (1983) style price-setting frictions. With probability $(1 - \theta)$, the firm reoptimizes $\tilde{P}_t$. With probability θ, $P_{i,t} = P_{i,t+1}$. The firm chooses its optimal price at time t, $\tilde{P}_t$, to maximize:

$$\max_{P_t} \sum_{j=0}^{\infty} (\theta\beta)^j \lambda_{t+j}^{b} (\tilde{P}_t Y_{i,t+j} - P_{t+j} mc_{t+j} Y_{i,t+j}) \,, \tag{27}$$

subject to the demand function.

$$Y_{i,t} = \left(\frac{P_{i,t}}{P_t}\right)^{-\frac{\gamma}{\gamma-1}} Y_t \,, \tag{28}$$

here, mc_t denotes the real marginal cost at time t:

$$mc_t = \frac{W_t^{\alpha}(R_t^{k})^{1-\alpha}}{P_t A \alpha^{\alpha}(1-\alpha)^{1-\alpha}} \,. \tag{29}$$

The optimal price is given by:

$$\breve{p}_t = \left[(1-\theta)\left(\frac{1-\theta\pi_t^{\frac{1}{\gamma-1}}}{1-\theta}\right)^{\gamma} + \theta\,\frac{\frac{\gamma}{\gamma-1}}{\breve{p}_t - 1}\right]^{-1} . \tag{30}$$

2.4 Government and monetary policy

For the government sector, we assume that government consumption of final goods is constant and that transfers are automatically adjusted at each date. The government's expenditures include consumption of final goods, payments to non-financial intermediaries, and unemployment benefits, while its revenue includes lump-sum taxes and interest on debt. The government faces the following budget constraint:

$$G_t + \tau\phi_t Q_t K_{t+1} + b_t(1 - L_t) + \phi_t Q_t Z_t = T_t + (R_{k,t} - R_t)\, B_{g,t} + B_{g,t+1} . \tag{31}$$

Unconventional monetary policy:

$$\phi_t = \bar{\phi}_t + \omega E_t[(logR_{k,t+1} - logR_{t+1}) - (logR_k - logR)] . \tag{32}$$

where $\bar{\phi}_t$ represents pandemic loans modeled as quantitative easing, but not exactly helicopter money as proposed by Friedman (1969), $\omega > 0$ is the Central Bank credit feedback parameter, and $(logR_k - logR)$ is the steady-state risk premium.

The Central Bank also conducts conventional monetary policy based on a Taylor rule, which relates the nominal interest rate R_t^* to its past value R_{t-1}^*, to the nominal inflation π_t^*, and to the output gap $(Y_t^* - Y_{t-1}^*)$:

$$R_t^* = \alpha R_{t-1}^* + (1 - \alpha)\, \alpha_\pi \pi_t^* + (1 - \alpha)\, \alpha_y (Y_t^* - Y_{t-1}^*) , \tag{33}$$

where α is the degree of interest rate smoothing, α_π is the weight on inflation, and α_y is the weight on the output gap.

We also have the Fisher relation that links nominal interest rates set by the Central Bank to the gross real interest rate set by the market:

$$1 + i_t = R_{t+1}\mathbb{E}_t\Pi_{t+1} . \tag{34}$$

Finally, market clearing conditions establish that production is divided between consumption, net investment, government expenditures on goods, and government financial intervention:

$$Y_t = C_t + I_{n,t} + f\left(\frac{I_{n,t}}{I_{n,t-1}}\right) I_{n,t} + G + \tau\psi_t Q_t K_{t+1} . \tag{35}$$

3 CALIBRATION AND MONETARY POLICY TO REDUCE THE EFFECTS OF COVID-19

3.1 Calibration

In this section, we outline the approach used to calibrate parameters for Morocco. Similar to Eichenbaum et al. (2020a, 2020b), we assume that each period in the model equates to one week, and it takes an average of 14 days for a patient to recover or die. As our model is weekly, we set $\pi_r + \pi_d = 7 \div 14$.

The computation of mortality rates is based on direct standardization, which eliminates disparities caused by factors affecting the mortality rate. This method is commonly used in demography for global comparisons when investigating demographic phenomena such as mortality and fertility. The aim is to assimilate the structure of the researched population to that of a reference group for which accurate information on Covid-19 is available (South Korea conducted the most tests for Covid-19 at the start of the pandemic); Borelli and Góes, 2020; Eichenbaum et al., 2020a, 2020b). We calculate a death rate in Morocco of 0.017%, which implies $\pi_d = 7 \times 0{,}017\backslash 14$.

As in Eichenbaum et al. (2020a, 2020b), we set $\mu_1 = 3.1949 \times 10^{-7}$, $\mu_2 = 1.5936 \times 10^{-4}$ and $\mu_3 = 0{,}4997$. These values must also satisfy the following system.

Let $D = \mu_1 C^2 + \mu_2 L^2 + \mu_3$ then we have:

$$\gamma_1 = \frac{\mu_1 C^2}{D}, \quad \gamma_2 = \frac{\mu_2 L^2}{D}, \quad \gamma_3 = \frac{\mu_3}{D}, \tag{36}$$

where C and L represent consumption and labor supply, measured by the number of hours worked. Note that the values γ_1, γ_2 and γ_3 represent the percentage of transmission that occurs in the market, at work, and in other activities, respectively. In the literature, these proportions are approximated to be 1/6, 1/6, and 2/3, respectively (Borelli and Góes, 2020; Eichenbaum et al., 2020a, 2020b).

The macroeconomic parameters in our model are in line with the literature on dynamic stochastic general equilibrium models and have been determined for the Moroccan case. We set the discount factor to its standard value of 0.98, a common choice in quarterly models. The utility function assigns a weight of 35 percent to leisure time, while the elasticity of substitution between intermediate inputs is calibrated to achieve a product markup of 25 percent. The degree of price stickiness is determined by expressing the standard quarterly Calvo probability of 0.70 in weekly units. The monetary policy reaction function includes interest rate feedback parameters for inflation and the output gap, which are set to 1.4 and 0.6 (converted to weekly), respectively, as per the standard Taylor rule. The elasticity of capital

Table 1 Parameter values

Parameter	Value	Description
π_d	0.001	Probability of death
π_r	0.499	Probability of recovery
ε_0	0.001	Initial infection
β	0.99	Discount factor
δ	0.025	Capital depreciation
α	0.3	Marginal productivity of labor
A	1	PTF SS
π_1	3.1949×10^{7}	Probability of a susceptible person becoming infected by consumption
π_2	1.5936×10^{-4}	Probability of a susceptible person becoming infected by hours worked
π_3	0,4997	Probability of a susceptible person becoming infected by other activities
π_r	1.5	Inflation rate Taylor Rule
π_x	0.5/52	Output gap

Source: Authors

β is calibrated assuming a labor share of approximately 3/4, while the bankers' survival rate is fixed at 0.970, representing an average tenure of 9 years. The share of unemployment compensation ξ is set at 0.6. The parameters for private banks, μ and , are determined to achieve a steady-state risk premium of 120 basis points and a leverage ratio of 5, consistent with Gertler and Karadi (2011). Table 1 provide a summary of the calibrated model parameter values. The multiple processes of solving and simulating the model were implemented using Matlab and Dynare software version 5.1 Documented in Adjemian et al. (2022).

3.2 Macroeconomic effects of infection shocks

Before registering of the first case of Covid-19 in Morocco in March 2020, the country's economy was growing steadily. In 2019, the Gross Domestic Product (GDP) increased by 2.3%, and the unemployment rate dropped to 9.2%. The government also launched several initiatives to attract foreign investment and promote economic growth, such as the Industrial Acceleration Plan and the Green Morocco Plan. However, the Covid-19 pandemic had a significant impact on the Moroccan economy. The government had to implement strict measures to control the spread of the virus, such as imposing a nationwide lockdown and closing borders, which led to a sharp contraction of economic activity. The International Monetary Fund (IMF) estimated that Morocco's GDP contracted by 6.3\% in 2020, while the unemployment rate increased to 12.5\%.

Similar to the methodology used by Eichenbaum et al. (2020), to consider the effect of the pandemic on labor supply and consumer demand simultaneously, both parameters π_1 and π_2 must be positive.

In this part, the transmission mechanism for a rise in infected persons in the economy is described. The dynamic responses of endogenous variables to the pandemic illness are shown in Figure 2 in the appendix and summarized in Table 2. The major consequence of the shock is a rise in the proportion of infected I_t, which is progressively mirrored a week later by an increase in the proportion of recovered R_t. A greater proportion of diseased persons translates to fewer susceptibles that are exposed E_t and quarantined Q_t. The figure shows that the model captures the main features of the recession. Output, consumption, investment, and hours worked fell sharply by 8%, 9%, 11%, and 12%, respectively. The decline in consumption reflects the likely decline in consumer demand. The large decline in investment reflects the size of the labor supply shock. As the data shows, the pandemic recession is accompanied by slight deflation. Moreover, we observe that households significantly reduce their consumption and work hours to reduce the probability of being infected.

The decline in output is a direct result of the increase in the proportion of infected individuals. Note that the reduction in production is caused by both supply and demand factors. On the one hand,

Table 2 Summary of effects of infection shocks

Economic and epidemiological indicators	Before the pandemic	During the pandemic
GDP growth	+2.3\%	–6.3\%
Unemployment rate	9.2\%	12.5\%
Economic production	-	–8.0\%
Consumption	-	–9.0\%
Investment	-	–11.0\%
Hours worked	-	–12.0\%
Inflation rate	1.2\%	–0.5\%
Proportion of infected individuals	-	High
Mortality rate	-	High

Source: Authors

the decrease in the marginal utility of consumption reduces the demand for output. On the other hand, the supply of output decreases due to the fall in TFP. Finally, Figure 1 also illustrates the impact of a pandemic in a model where prices are both flexible and sticky. We can observe that the recession is slightly more severe when prices are rigid. The main difference between the two models is related to inflation. The flexible price model predicts a greater decline in prices than the sticky price model.

Figure 1 Epidemic as a shock to consumption demand and labor supply

Note: See the online version of *Statistika: Statistics and Economy Journal* No. 3/2024: <*https://doi.org/10.54694/stat.2024.8*>.
Source: Authors

3.3 Monetary policy shock during a pandemic

In this part, we evaluate the use of Unconventional monetary policy by Bank al Maghrib to mitigate the effects of the Covid-19 pandemic and how this policy can create today's inflation. As well as the Vásconez et al. (2021) we suppose of Unconventional monetary policy by Bank al Maghrib. Our definition of this policy is an extreme version of Quantitaive easing policy, but not quite "helicopter money" as described by Friedman (1969). Instead of distributing money directly to people with no prospect of being returned, the Central Bank raises its percentage of total claims issued, and firms subsequently acquire capital without having to transit through private banks. Thus our unconventional policy directly influence demand by motivating investment, and should be conceived of as growing Central Bank intermediation rather than expanding the money supply.

Figure 2 IRFs to unconventional monetary policy shocks

Note: See the online version of *Statistika: Statistics and Economy Journal* No. 3/2024: <*https://doi.org/10.54694/stat.2024.8*>.
Source: Authors

Lowering the policy rate is a commonly used monetary policy tool to stimulate economic growth. The theoretical basis for this policy is that by lowering the interest rate, households and firms are encouraged to borrow more money and spend it on consumption and investment, respectively. This increased spending leads to a boost in aggregate demand, which can help increase output and employment. Empirical studies have shown that lowering the policy rate can indeed stimulate household consumption. For example, research has found that when interest rates are lowered, households are more likely to take out mortgages and consumer loans, which can lead to increased spending on housing and durable goods. However, the impact of lowering the policy rate on output is not significant. While some studies have found a positive relationship between interest rates and output, others have found no significant impact. One reason for this is that the transmission mechanism from interest rates to output is complex and may be influenced by factors such as credit availability, exchange rates, and government policies.

It is possible that the non-significant impact on output in this scenario could be due to other factors that are dampening the effectiveness of the policy. For example, if households are highly indebted or if there is a lack of investment opportunities, then even with lower interest rates, they may not increase spending as much as expected. Additionally, if there are supply-side constraints, such as a shortage of skilled workers or limited access to raw materials, then even if demand increases, output may not be able to keep up without compromising the effects of Covid-19. Overall, while lowering the policy rate can encourage households to consume more, its impact on output may be less clear and influenced by various other factors. Lowering the policy rate can also lead to an increase in inflation if it stimulates too much demand in the economy. As households and firms borrow more and spend more, the increased demand can push up prices, especially if there is limited capacity to produce more goods and services.

Inflation erodes the purchasing power of money, which can lead to a decline in real investment and a decrease in the net wealth of banks. Additionally, higher inflation can lead to a rise in interest rates, which can further reduce investment and hurt the banking sector.

The sharp increase in credit offered by banks in response to lower interest rates is a common phenomenon, as it becomes more profitable for banks to lend money when the interest rates are low. However, excessive lending can lead to an increase in credit risk and potentially to financial instability if borrowers are unable to repay their loans. It is important for monetary authorities to monitor inflation and credit growth closely and adjust interest rates accordingly to maintain stability in the economy. If inflation becomes too high, central banks may need to raise interest rates to cool down the economy and prevent inflation from spiraling out of control. Similarly, if credit growth becomes excessive, regulatory authorities may need to impose limits on bank lending to prevent a buildup of financial risks.

Overall, while lowering the policy rate can stimulate economic activity during Covid-19, it can also lead to higher inflation and excessive credit growth, which can have negative effects on investment and financial stability. Monetary authorities need to carefully balance the benefits and risks of this policy tool and use it judiciously to achieve their policy objectives. Our results are in line with those proposed by Sharma et al. (2020), Céspedes et al. (2020), and Kiley (2020).

CONCLUSION

The Covid-19 pandemic has had a significant impact on the global economy, including the Moroccan economy. The pandemic has led to a sharp decline in economic activity, disruptions in supply chains, and a reduction in international trade. In response to the economic challenges posed by the pandemic, Bank Al-Maghrib, the central bank of Morocco, has taken a number of measures to support the economy and ensure financial stability. In March 2020, Bank Al-Maghrib lowered its policy rate by 25 basis points to 2%. This decision was aimed at supporting economic activity and ensuring the availability of credit to households and businesses. Additionally, the central bank implemented a number of liquidity support measures, such as reducing reserve requirements and providing loans to banks at a lower interest rate.

Studies of other nations have shown that these measures have had a positive impact on household consumption in Morocco. For example, a study by the African Development Bank found that the reduction in interest rates led to an increase in bank lending to households and businesses. This, in turn, contributed to an increase in consumption and investment, which helped to support economic growth.

However, the impact of these measures on output is less clear. While some studies have found a positive relationship between interest rates and output, others have found no significant impact. One reason for this is that the transmission mechanism from interest rates to output is complex and may be influenced by various factors, such as the availability of credit and supply-side constraints. Overall, Bank Al-Maghrib's policy response to the Covid-19 pandemic has been aimed at supporting economic activity and ensuring financial stability. While the measures taken have had a positive impact on household consumption, their impact on output is less clear and may be influenced by various factors. In addition, some studies have also highlighted the potential risks of these measures. For example, the reduction in interest rates could lead to higher inflation and a decrease in the net wealth of banks, which could affect their ability to provide credit in the future. Therefore, it is important for Bank Al-Maghrib to carefully balance the potential benefits and risks of its monetary policy decisions in response to the Covid-19 pandemic.

In light of these challenges, our study aims to provide a deeper understanding of the potential impact of unconventional monetary policy on the Moroccan economy in the context of the Covid-19 pandemic. By using a DSGE model that incorporates both epidemiological and economic dynamics, furthermore, our study contributes to the broader theoretical and empirical literature on the use of unconventional monetary policy in the context of the Covid-19 pandemic. By building on previous research in this area, we aim to further our understanding of the mechanisms through which these policies can impact economic outcomes and the conditions under which they are most effective. Ultimately, our study may supply information for policy debates around the use of unconventional monetary policy in the context of future economic shocks, both in Morocco and other countries around the world.

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