International Journal of New Political Economy 5(1): 239-268, 2024

An Optimal Monetary Policy in a Long- Run Coexistence with COVID-19

Iman Bastanifar[1]*

ARTICLE INFO

Article history:

Date of submission: 27-06-2023

Date of rivise 27-09-2023

Date of acceptance: 07-10-2023

JEL Classification:

E580

I180

Keywords:

Shopping time

Discount rate

Rule

Dynamic programming

CFR

ABSTRACT

With the advent of COVID-19 health authorities of most Top high GDP countries dominated the economy. A policy response to COVID-19 pandemic, was the lockdown policy. I show that this discretionary biological health policy in a new shopping time model by dynamic programming technique, decrease the value of transaction time saved by holding additional money and increases the real balance of money during COVID-19. An optimal monetary policy rule during COVID-19 is a rule, based on that, the growth rate of banking discount rate equals the variation of case fatality risk (CFR). This rule is computed as an optimal monetary policy rule for each month of the top 15 GDP countries of the world in 2020. The results show that the rate of rapid and hasty reduction of the announced discount rates during the COVID-19 period were not optimal and would be one of the reasons for the occurrence of inflation and the failure of the inflation target policy in recent years. Therefore, I recommend a rule to determine an optimal monetary policy when our world experiences a biological shock.

1. Assistant Professor of Economics, Faculty of Economics and Administrative Sciences, University of Isfahan

*** Corresponding Author Email Address:** i.bastanifar@ase.ui.ac.ir

DOI: https://doi.org/10.48308/jep.5.1.239

1. Introduction

According to Keynes's theory of demand for money in his well- known book" Theory of Employment, Interest rate and Money"(1936), precautionary motivation for holding money is one of the three motivations happening in an uncertain situation. This means that in an uncertain situation people prefer to hold money. Therefore, it is not far from the Keynes's theory to explain the uncertainty created in the world due to Covid_19. If it is assumed that Covid_19 is one of the sources of uncertainty, people would prefer to hold more money. In this situation, governments meddle with the economy by discretionary health interventions. These polices have been started with the rapid spread of COVID-19 in all of the world. These interventions are done through epidemiological policies. According to the dictionary of epidemiology, "Epidemiology is the study and analysis of the distribution (who, when, and where), patterns and determinants of health and disease conditions in defined populations. It is a cornerstone of public health and shapes policy decisions and evidence-based practice by identifying risk factors for disease and targets for preventive healthcare" (Porta,2014). One of the common strategies that epidemiologists apply is lockdown policies or Non-Pharmaceutical Interventions (NPLs) to control the spread of the disease. The severity of these policies (stay-at-home orders, curfews, quarantines, cordons sanitaires, and societal restrictions) depends on health reports. These reports are related to some ratios such as Case Fatality Risk[1],(CFR)[2]. The dominance of the health authority forces the social planner to pursue lockdown policies. These policies affect economic activities (Barro and Ursúa, 2020). Within the framework of the theoretical literature of time inconsistency, policies are divided into two levels of announcement and action[3] (Bastanifar et al 2013). Since preferences of the health authority and the household are not necessarily consistent, a health

1. "Case fatality rate, also called case fatality risk or case fatality ratio, in epidemiology, the proportion of people who die from a specified disease among all individuals diagnosed with the disease over a certain period of time." (Harrington, 2008). https://www.britannica.com.
2. www.cebm.net/covid-19/global-covid-19-case-fatality-rates.
3. Mankiew (2003), declares “discrepancy between announcements (what policymakers say they are going to do) and actions (what they subsequently in fact do) is called the time inconsistency of policy”.

policy design that leads to an announcement or policy is not successful in implementation (action). This gap between ex-ante and ex-post health lockdown policies is the time inconsistency of health discretion policy. People hoard essential commodities (e.g., food, medicines) during the lockdown and save money as they are worried about their health and lives (Barua, 2021). Therefore, if lockdown policies failed and could not control the spread of Covid_19, it would act as a source of uncertainty and lead to increase the demand for money, according to Keynes's theory of demand for money. But in recession, transaction demand and speculation decrease against the precautionary demand for money. Therefore, if, the growth rate of money (broad or narrow) increased during the period of Covid_19 it means that the effect of precautionary demand on money (increasing effect) would outweigh the other two effects (decreasing effects). Thus, the social planner, on one hand, must control the COVID-19 pandemic by lockdown policies and on the other hand have to control the effect of them (uncertainty of economic activities).

But how long do these interventions last? "Are we hearing the voice of John Maynard Keynes for more than Herbert Hoover’s. At least for a moment, we were all Keynesians, "(Stiglitz, 2021)? Or we have to hear the new voice of Kydland and Prescott (1977), the economic noble winners of 2004, "Rule, rather than health discretion, double time inconsistent of an optimal plan?" Should we always be optimistic about the future of the economic recovery after- COVID-19 by designing a modern monetary theory and policy whose main focuses are on money financed deficits?.

In the short- run, we have health dominance. This type of dominance causes discretion and affects inconsistency and uncertainty. Therefore, a benevolent social planner (who hears the voice of both the health authority and the monetary authority) needs a long-run augmented epidemiological contingent[1] rule in economics. This rule should also take into account the extent to which individuals are willing to accept health protocols and adapt them quickly. This rule enables coexistence with COVID-19 in the long run. Monetary policy is one of the most common ways to prevent a recession. In

1. This term is found at the works of Barro and Gordon (1983a&b) & Barro (1986). This rule pays attention to the effect of trust between planner and people. (Barro and Gordon 1986, 103).

the literature of rule and discretion, an optimal monetary policy rule is a way to control time inconsistency (Tabellinin, 2005). Therefore, if this rule is based on epidemiological considerations it can minimize the economic and social losses of COVID-19 and maximize the welfare of households.

In this paper first, after introduction, I focus on some important information of the top 15 GDP countries of the world in 2020. These countries are the United States, China, Japan, Germany, United Kingdom, India, France, Italy, Canada, South Korea, Russia, Brazil, Australia, Spain, and Indonesia, which account for about 76% of world nominal GDP (https://globalpeoservices.com). They have approximately 55% of the world's population (https://www.worldometers.info/world-population) and also had a high proportion of corona infection and death during the different months of 2020[1]. Second, I explain literature review and the shopping time model. The next section is about model that is considering by epidemiological decision-maker and extract an optimal monetary policy rule in the coexistence with COVID-19, results, and discussion. The last part is the conclusion.

2. Data Observations in the top 15 GDP Countries

Table (1) shows the share of 15 Top GDP countries from the GDP of the world, population (PoP), and COVID-19 case and dead, at the end of 2020. Table (2) shows the variation of discount rate policy in these countries. Some countries changed discount rates drastically only in one month (like USA, UK, Canada, in March and S. Korea in Feb.). But, some countries altered discount rates gradually throughout the year and several times in different months (Like Russia, Brazil, Australia, Indonesia, and India). Some countries, member of EUR, [2] GIFS and China did not change it. In Japan, the discount rate was approximately unchanged (small increasing only in Feb). Table (3) shows the growth of [3]broad money between 2016 and 2020. This shows that in 2020, the

1. https://www.worldometers.info/coronavirus
2. GIFS is the abbreviation of Germany, Italy, France, and Spain, Members of Euro Zone.
3. The narrowest measure of money that the Fed reports is M1, which includes currency, checking account deposits, and traveler's checks. The M2 monetary aggregate adds to M1 other assets like Small-denomination time deposits and repurchase agreements plus Savings deposits and money market deposit accounts plus Money market mutual fund shares (non institutional). M3 or broad

broad money grow up more than the other years. Much of the changes in broad money are due to rapid changes in narrow [1]money (This sudden M3 growth in 2020, is the contribution of discretionary health interventions that forced the economic authority to apply discretionary monetary policies (such as quantitative easing, debt bond issuing, discount rate, etc.) [2].

Table 1. Share of 15 Top GDP countries from GDP, population, and COVID19 Cases and deaths from the world[3]

County	[4]% GDP	% Case	% Dead	% Population
USA	24.77	24.88	19.55	4.25
China	17.69	.10	.01	18.47
Japan	5.85	.27	.18	0.48
Germany	4.50	2.08	1.85	1.07
UK	3.14	2.96	3.98	0.87
India	3.10	12.27	8.06	17.7
FRANC	3.04	2.93	3.50	0.84
Italy	2.20	2.53	4.01	0.78
Canada	1.90	.69	.84	0.48
South KO	1.89	.07	.05	0.66
Russia	1.74	3.77	3.08	1.87
Brazil	1.62	9.16	10.54	2.73
Australia	1.58	0.03	0.05	0.33
Spain	1.49	2.35	2.75	0.6
Indonesia	1.30	.89	.92	3.51
Total	75.81	64.99	59.36	54.64

Source: Research finding

money is M2 in addition to Large-denomination time deposits and repurchase agreements, Money market mutual fund shares (institutional), Repurchase agreements and Eurodollars(Mishkin,2004,p.53)

1. https://data.oecd.org/money/narrow-money-m1.htm#indicator-chart.
2. For example $\frac{M_1}{M_3}$ in the USA was 26% in 2020-01-01 and this ratio has increased to 93% in 2021-01-01. The monthly average from 1960-01-01 to 2019-12-01 was 28%. (https://fred.stlouisfed.org).
3. https://globalpeoservices.com, Case and dead from https://www.worldometers.info/coronavirus. Population from, https://www.worldometers.info/world-population
4. The Columns show each country's proportion of each GDP, Case of Covid_19, Dead by covid_19 and population of the world respectively.

Table 2. Interest rate policy (%) in Top 15 GDP in 2020 during Covid19

	[1]*USA	*China	**Japan	GIFS	*S.Korea	UK	Canada	Russia	*Brazil	Australia	Indonesia	India
Ja	2.25	2.9	0.1	0	0.5	0.75	1.75	6.25	10.66	0.75	5	5.4
Fe	2.25	2.9	0.3	0	0.25	0.75	1.75	6	10.44	0.75	4.75	5.4
Mar	0.25	2.9	0.3	0	0.25	0.1	0.25	6	10.19	0.25	4.5	4.65
App	0.25	2.9	0.3	0	0.25	0.1	0.25	5.5	9.87	0.25	4.5	4.65
May	0.25	2.9	0.3	0	0.25	0.1	0.25	5.5	9.19	0.25	4.5	4.25
Jun	0.25	2.9	0.3	0	0.25	0.1	0.25	4.5	8.73	0.25	4.25	4.25
Jul	0.25	2.9	0.3	0	0.25	0.1	0.25	4.25	8.28	0.25	4	4.25
Aug	0.25	2.9	0.3	0	0.25	0.1	0.25	4.25	8.05	0.25	4	4.25
Sep	0.25	2.9	0.3	0	0.25	0.1	0.25	4.25	8.01	0.25	4	4.25
Oct	0.25	2.9	0.3	0	0.25	0.1	0.25	4.25	8.01	0.25	4	4.25
Nov	0.25	2.9	0.3	0	0.25	0.1	0.25	4.25	8.01	0.1	3.75	4.25
Dec	0.25	2.9	0.3	0	0.25	0.1	0.25	4.25	8.01	0.1	3.75	4.25

Source: Research finding

According to the information of the website of global-rates.com, information of European interest rate is illustrated at the bellow graph. The interest rate of the European Central Bank (ECB) was zero between 2015 - 2022. Therefore, GIFS, members of ECU, had to follow zero interest rate during Covid_19 in 2020.

3. Literature review

The theoretical literature of this research is classified into two parts. The first is about the global recession created by COVID-19 and lockdown policies. The second is about shopping time models.

1. Reference: * Data from https://fredhelp.stlouisfed.org . For Indonesia, data is from https://tradingeconomics.com/indonesia/interest-rate. For japan, from https://ycharts.com/indicators /bank_of_japan_basic_discount_rate_daily. For others, https://www.global-rates.com.

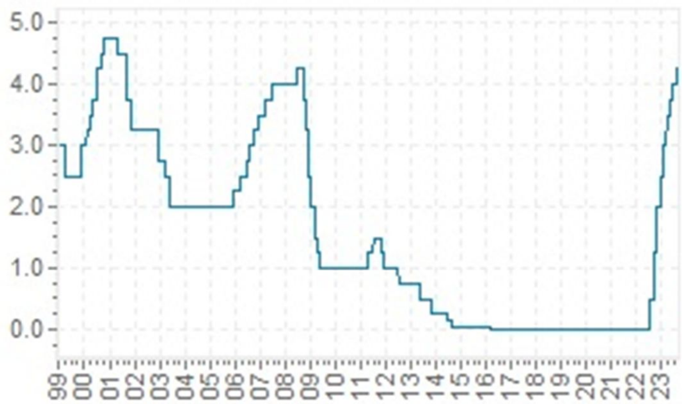

Fig1. European interest rate ECB - long-term graph[1]

Table 3. Broad money Growth in 15 Top GDP world's of 2020[2]

Countries	M3 growth rate%	Countries	M3 growth rate%	Year
*USA	7.05	*China	8.17	2016
	4.82		8.94	2017
	3.73		8.74	2018
	6.64		10.08	2019
	24.60		Not available	2020
*Japan	3.35	**Germany	5.25	2016
	3.07		4.08	2017
	2.11		4.4	2018
	2.26		4.86	2019
	7.60		8.51	2020
*UK	9.81	*India	6.23	2016
	6.33		10.19	2017
	3.81		9.62	2018
	0.00		11.10	2019
	12.67		11.70	2020

1. https://www.global-rates.com/en/interest-rates/central-banks/european-central-bank/ecb-interest-rate.aspx
2. M3 or broad money for Italy, French, Germany and Spain is Depository Cooperation Survey, Broad Money Liabilities (Euro Area-Wide-Residency), Euros.

Countries	**M3 growth rate%**	**Countries**	**M3 growth rate%**	**Year**
*USA	7.05	*China	8.17	2016
	4.82		8.94	2017
	3.73		8.74	2018
	6.64		10.08	2019
	24.60		Not available	2020
**Franc	6	**Italy	4.71	2016
	7.4		4.31	2017
	4.34		2.49	2018
	5.83		5.78	2019
	16.76		10.58	2020
Countries	M3 growth rate%	Countries	M3 growth rate%	Year
*Canada	10.80	*South K.	7.51	2016
	5.08		6.53	2017
	3.95		7.60	2018
	2.21		7.96	2019
	20.61		8.22	2020
*Russia	1.48	*Brazil	10.62	2016
	7.50		7.44	2017
	12.40		9.66	2018
	5.13		7.68	2019
	16.70		17.70	2020
*Australia	6.91	**Spain	5.98	2016
	4.72		1.61	2017
	2.63		4.1	2018
	2.53		3.36	2019
	12.96		10.27	2020
**Indonesia	10.03			
	8.28			
	6.29			
	6.54			

Sources:"*", Data from https://fredhelp.stlouisfed.org and "**" From https://data.imf.org. Growth Calculation by Author.

3.1. Global recession created by COVID-19 and lockdown policies

The global recession created by COVID-19 can be examined in two categories. One is the economic effect of the COVID-19 regardless of lockdown policies. In these studies, such as Barua (2021), macroeconomics effects such as demand and supply shocks, supply chain, trade, investment, price level, exchange rates, financial stability, risk, economic growth, and international cooperation, during COVID-19 are being investigated. According to Baldwin, and Dimauro (2020), COVID-19, acts as a shock on both demand and supply sides, aggregate trade flows, significantly manufacturing and supply chain distortions. Baldwin, and Dimauro (2020), Fornaro and Wolf, (2020) show that the spread of the COVID-19 outbreak might cause stagnation traps induced by pessimistic animal spirits. Other lines of these studies such as Beck (2020), - Cecchetti (2020) focus on the finance and banking risks created by the pandemic. The second category of the surveys is the role of locking policies against COVID-19. These models apply the epidemiology models of COVID-19 and lockdown policy against COVID-19. Epidemiological models are based on mathematical infectious diseases. Population in this model are assigned to three (susceptible, infectious, and removed or SIR) or more compartments.

The earliest works being that of Ross (1916), Ross, and Hudson (1917). Kermac, and Mckendrick, (1927), and Kendall, (1956). In some new mathematical model of dynamics literature of covid19, (such as Ivorra and et al (2020), personal health is in nine compartments such as "Susceptible", Expose", "Infectious","Infectious but undetected", "Hospitalized or in quarantine at home", "Hospitalized that will die", "Dead by COVID-19", "Recovered after being previously detected as infectious" and "Recovered after being previously infectious but undetected".

Lockdown policies against COVID-19 such as stay-at-home orders, curfews, quarantines, cordons sanitaires, and societal restrictions focus on the time management of diffusion controls. For example, Alfano, and Ercolano (2020), using a quantitative panel analysis, data from 202 countries around the world, from 22 January to 10 May 2020; show that lockdown policy (from 7 to 20 days) is effective in reducing the number of new cases around 10 days after the implementation of the policy. It's efficacy continues to grow up to 20 days after implementation. CFR (Case Fertility Rate or Risk) in this model is important as a ratio to control Public health and planning. For example, Alvarez et al (2021), using a simple optimal control model in the SIR epidemiology model show that the intensity of the lockdown policy depends on the fatality rate variation.

Another factor of a lockdown policy efficacy is complying with the community. The legal aspect of protocols is important. Disemadi, and Handika (2020), used a socio-legal research method with a normative legal approach and a sociological approach conducted in Klaten-Central Java of Indonesia. The result shows that the policy currently being taken is health quarantine and the policy is the issuance of health protocols for the community. Nivette et al (2021) investigate Non-compliance of young adults in Switzerland with 737 samples at age 22 with COVID-19-related public health measures. They find that Non-compliance, especially with hygiene-related measures, was more prevalent in males. Implementation of a lockdown policy may be mandatory or voluntary. Chudic et al (2021), estimate time-varying COVID-19 reproduction numbers based on a moment condition that can be derived from an agent-based stochastic network model of COVID-19 transmission. They show that people's behavior in the selected countries include most of the G20 economies with the widest regional coverage globally depends on the voluntary or government-mandated isolation that affects the transmission rate. Since time is an important factor in lockdown models, a time-based model must be considered to combine with a monetary model. Now, I review the literature on shopping time models.

3.2. Shopping Time models

In a conventional shopping time model (Walsh, 2017), a representative household utility, v[c,l], depends on consumption(c) and leisure(l) and leisure is equal to l=1-n-n^s. Where n is time spent in market employment and n^s is time spent for shopping. Time is normalized equally to one. The shopping time requires levels of consumption and money holdingn^s=g(c, m). This function is an increasing function to consumption and decreasing function to real money balances:g_c>0 and $g_m \leq 0$. Now a representative household utility defines as

$$u(c_t, m_t, l_t) \equiv v[c_t, 1 - n_t - g(c_t, m_t) \quad (1)$$

In this model, the utility for holding money is indirect. It is assumed that shopping time decreases leisure time and the household holds money to decrease the time of payment. Therefore, money, in a real balance form, increases leisure time. Time sensitivity in this model is extended in an expert field such as dealer behavioral or banking time. Umesh et al (1989), expand the effect of time, according to the personality of a dealer. They show that for consumers encounter deal, a deal proneness affects the shopping time and holding the money. Gillman (2020), used banking production time instead of shopping time to estimate the welfare cost of inflation for the USA. No research has been done so far, that expands the time of shopping during the COVID-19 economy with voluntary lockdown policies. Therefore, at first, we need a new kind of combined model (ecology and monetary economics), that shows the effect of discretionary health interventions on the process of household optimization. Second, in this model, a representative household will be free to accept the health decisions. I call this kind of model[1] the Frechlod Augmented Shopping Time model. In the following, the model of the article is introduced.

1. Freedom to choose a Lockdown

4. Model

This section first introduces the conceptual model. Then the model assumptions are presented and the new shopping time model is introduced. In the following, the solving model, numerical analyzes, and discussion are presented.

4.1. The conceptual model

The intervention of health centers leads to discretionary health announcements or policies. The household has two choices in accepting or rejecting health lockdown policies again Covid-19. These policies include maintaining social distance, quarantine, traffic restrictions, etc. They also affect the time of shopping. If people accept these policies (based on the degree of household's trust in the planner), a queue will be formed for shopping. I call this type of queue a vertical queue because people are healthy and able to stand in this queue. If people do not accept, they are more likely to get the virus and have to be hospitalized for some time. So hospitalization queues will be formed. I call this type of queuing, in which people have to be placed in a hospital or home beds, a horizontal queue. Therefore, the time of hospitalization is the cost of the opportunity to not accept health restrictions. This time, in proportion to the immune system of individuals, can be more, less, or equal to the time delay in the vertical queue due to health restrictions. The body's immunity plays an important role in getting out of the horizontal queue and achieving health. The household with lower immunity needs to be hospitalized longer. Therefore, since the preference of the health authority is not the same as the preference of the household, a discretionary health policy creates two choices for individuals (to accept or non-accept). This conflict in preferences creates a gap between the announcement (ex-ante) and performance (ex-post) of a health policy. This gap or inefficacy of a lockdown policy in implementation means that the discretionary health authority's policy has caused a time inconsistency. A rational household with knowledge of its immune system may require the implementation of some health policies. Either way, the possibility of acceptance or not, health interventions will reduce the household's leisure time and their utilities. It will be looking for a tool to get out of vertical and horizontal queues faster. Money in a form of real balance can play this role. Figure (2) shows the effect of health intervention.

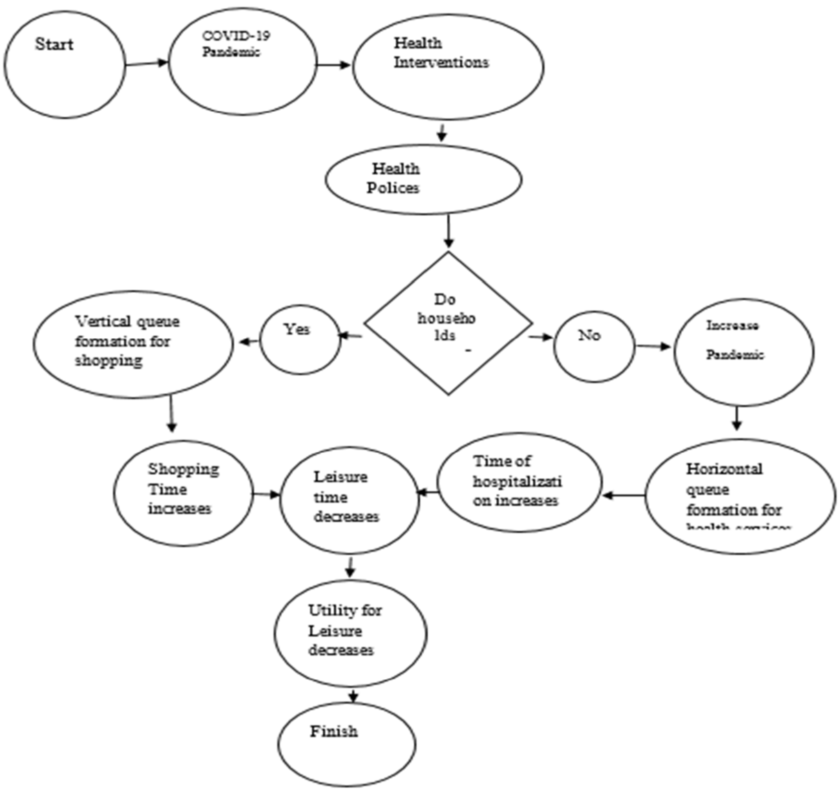

Fig 2. COVID19 Pandemic effect on Leisure time**,**

Source: Research finding

Figure (3), the conceptual model, shows how additional demand for money is formed in response to a discretionary health policy. If the households accept health policies, they hold money for using alternative tools (like e-shopping) to pay faster and reduce shopping time, but if they do not accept, they need a tool (money) to decrease the time of possible hospitalization and its costs. More money is used for the possible costs of hospitalization, medicines, immunization tests, and so on. So the demand for more money is the reaction of the households to discretionary health interventions to get out of the vertical and horizontal queues faster. I call this effect, getting out money. That means, additional holding money to get out of the queue faster. This effect is illustrated in color in Fig (3). This effect increases the demand for real balance in an economy during COVID-19. Now, by imposing the assumptions on the conceptual model, I propose the new shopping time to extract the optimal monetary policy rule.

4.2. Assumptions

A- The interventions of the health authority are non-pharmaceutical or lockdown policy[1] against COVID-19.

B- The above interventions lead to the formation of discretionary health policies like isolation, quarantine, tracing, public social distance, closing jobs, staying at home, etc. The severity of the intervention depends on the CFR ratio.

C- People have the freedom to choose whether to accept or reject health policies.

D- The real money balance can make it faster to get out of the vertical and horizontal queues.

E- The labor market is not sticky, and health authority does not affect aggregated production.

Indeed, it is possible to move labor to another market. The products are in long-term equilibrium and full employment.

F- The long-run population growth rate is constant and exogenous.

G- Demographic structures are constant (like age, sex, gene).

H- Inflation and population growth rate are exogenous.

1. For example, stay-at-home orders, curfews, quarantines, cordons sanitaires, and societal restrictions.(such as social distance)

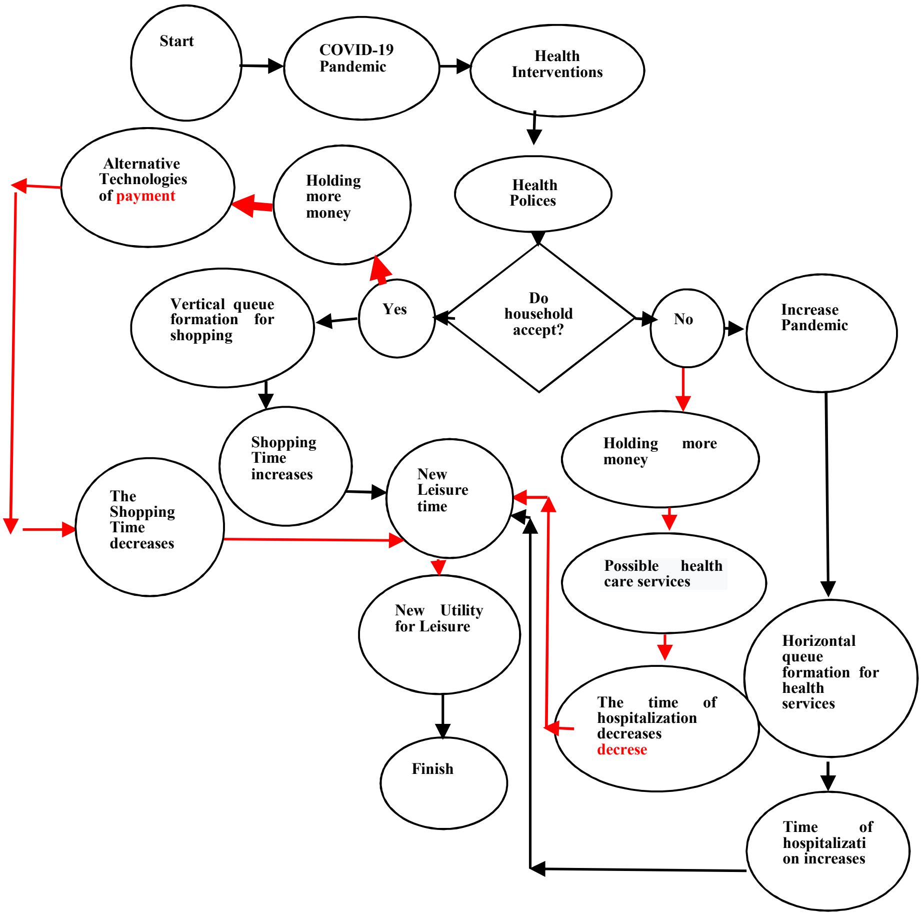

Fig 3. Money holding in COVID19 Pandemic environment

Source: Research finding

4.3. The new shopping time model

As it is illustrated in figure (1), the household can accept or reject health policy with a certain degree of probability. So equation (2) can be written as follows:

$$l_{tc} = [1 - n_t - Prn^{(c_s)} - (1 - Pr)n^{(c_h)}] \tag{2}$$

l_{tc} , is the leisure time during COVID-19. Pr , is the likelihood that household accept the health policies. 1- Pr , is the likelihood that people does not accept it[1].

n^{c_s} is shopping time during COVID-19. n^{c_h} is time for care (hospitalization or home quarantine due to COVID-19). According to assumption "B", a health decision or policy depends on CFR. It is assumed that this effect, mathematically is exponential as follows:

$$n^{(c_s)} = g(c, M)e^{(CFR_t)} \quad (3)$$

CFR is the proportion of dead to case in a special time (For this paper monthly). Equation (3) shows that any increase in CFR will increase the severity of health decisions and impose more health restrictions. This makes the vertical queues longer and increases the shopping time. As it is illustrated in Figures (1) & (2), if the public does not accept health policies, they have to pay the opportunity cost for this non-acceptance. This is the time of hospitalization. The time of hospitalization depends on the household's immune system. According to World Health Organization (WHO), in 2021. 10 May " The immune response following infection with a virus can be measured by the detection of virus-specific antibodies such as IGA, IGM, IGG or total antibodies through of immune response or IM index as a risk–free certificate. This index is an important factor for the time of hospitalization. The exact relationship between this index and immunity passport, IGA, IGM, IGG, or total antibodies needs more information about the COVID-19 that is not yet available. I have stated this index simply to show the adverse effect of the household's immune system on hospitalization time.

Therefore, this time equals to, more or less than shopping time. A household with a low immunity degree, (near to zero) must spend more time

1. This likelihood depends on the sociodemographic variables relevant for understanding protective health behaviors and non-compliance and also trust to the authorities. In this model, it is considered exogenous.

for curing than a household with high immunity (near to one). If this degree is defined between zero to one, $1 > Im. > 0$ therefore:

$$n^{(c_h)} = g(c, M)e^{(CFR_t)}.\frac{1}{\text{Im}} \tag{4}$$

Now, by replacing equations (3) and (4) in equation (2), the new leisure time that is illustrated in figure (2), is specified as follow:

$$l_c = [1 - n - Pr.g(c, M)e^{CFR_r} - (1 - Pr)g(c, M)e^{CFR_r})\frac{1}{\text{Im}}] \tag{5}$$

By substituting equation (5) for the leisure in the utility function, we have the new utility function included COVID-19 as follow:

$$u(c, m, l) = v\left\{c, 1 - n - g(c, M)e^{CFR_t}[pr + (1 - pr).\frac{1}{\text{Im}}]\right\} \tag{6}$$

In the above equation[1], $e^{CFR_t}[(pr + (1 - pr)\frac{1}{Im}]$ is the disutility effect of health interventions in a COVID-19 environment, that is imposed on a representative household due to discretionary health policies. I show this effect by COV_t.

Now I write a representative household intertemporal utility function.

$$\sum_{j=0}^{\infty}\beta^j v[c_{(t+j)}, 1 - n_{(t+j)} - g(c_{(t+j)}, m_{(t+j)})COV_t] \quad 0 \leq \beta \leq 1 \tag{7}$$

Where β is a factor of discounting and shows the time preference of an household. c_t is time t per capita consumption.

Subject to:

$$A_t = \tau_t.N_t + \frac{(1 + i^g_{(t-1)})B^g_{(t-1)}}{P_t} + \frac{(1 + i^m_{(t-1)})M_{(t-1)}}{P_t} \tag{8}$$

1. The idea of using parameter in utility is also in Lucas and Stokey (1983), Lucas (2000), in order to estimate endogenous velocity of money (Gillman, 2009).

A_t is a non human wealth. τ_t is transfer paymeny.B is total debt of a government. i_{t-1}^{g} is government bond yield and i_{t-1}^{m} is interest on money. P_t is price index. M_{t-1} is stock of money.

$$Y_t + (1-\delta)K_{(t-1)} + A_t \geq C_t + K_t + \frac{M_t}{P_t} + \frac{B^g{}_t}{P_t} \qquad (9)$$

Y_t is aggregate production function. $Y_t = F(K_{t-1}.N_t.\theta_t)$.

K_{t-1} is the aggregate stock of capital at the end of period t-1. N_t is population. θ_t is technology. $\tau_t N_t$ is the aggregate real value of any lump-sum transfers or taxes and, δ is rate of depreciation of physical capital. According to assumption "H", P_t =(1+π_t) P_{t-1} and N_t =(1+n) N_{t-1}. Dividing both sides of the budget constraint (8) and (9) by population (N_t).

$$\frac{A_t}{N_t} = a_t = \tau_t + \frac{(1+i_{t-1}^{g}).B^G{}_{t-1}}{(1+\pi_t)(1+n)P_{t-1}.N_{t-1}} + \frac{(1+i_{t-1}^{m})M_{t-1}}{(1+\pi_t)(1+n)P_{t-1}.N_{t-1}} \qquad (10)$$

or $$a_t = \tau_t + \frac{(1+i_{t-1}^{g}).b^g{}_{t-1}}{(1+\pi_t)(1+n)} + \frac{(1+i_{t-1}^{m}).m_{t-1}}{(1+\pi_t)(1+n)} \qquad (11)$$

Now, the per capita budget constrain becomes:

$$y_t + \frac{(1-\delta)}{(1+n)}k_{(t-1)} + a_t \geq c_t + k_t + m_t + +b_t^g \qquad (12)$$

4.4. Solving the model

$W(a_t.k_{t-1})$ is the value function.

$$\begin{aligned} W(a_t, k_{(t-1)}) &= Max[V(c_t.1-n_t - g(c_t.m_t)COV_t)] + E_t W(a_{(t+1)}.k_t) \\ &= Max[v(c_t.1-n_t - g(c_{(t+j)}, m_t)COV_t)] + E_t W[\tau_{(t+1)} \\ &\quad + (\frac{(1+i_t^g).b^g{}_t}{(1+\pi_{(t+1)})(1+n)}) + \frac{(1+i_t^m)m_t}{(1+\pi_{(t+1)})(1+n)}), \\ &\quad (y_t + \frac{(1-\delta)}{(1+n)}k_{(t-1)} + a_t - c_t - m_t - b^g{}_t)] \end{aligned} \qquad (13)$$

By using these two constraints to eliminate k_t and a_{t+1} from the expression for the value function, the necessary first-order conditions for labor, consumption, real money holdings, real bond holdings, are :

$$\frac{\partial W(a_t, k_{(t-1)})}{\partial n_t} = \frac{\partial V}{\partial l_t}.\frac{\partial l_t}{\partial n_t} + \beta E_t \frac{\partial W(a_{t+1}, k_{(t)})}{\partial k_t}.\frac{\partial k_t}{\partial f}\frac{\partial f}{\partial n_t} = 0$$
$$\Rightarrow -v_l + \beta E_t \frac{\partial W(a_{t+1}, k_{(t)})}{\partial k_t} f_n = 0 \qquad (14)$$

$$\frac{\partial W(a_t, k_{(t-1)})}{\partial c_t} = \frac{\partial V}{\partial c_t} + \frac{\partial V}{\partial l_t}\frac{\partial l_t}{\partial g}\frac{\partial g}{\partial c_t} Cov_t - \beta E_t \frac{\partial W(a_{t+1}, k_{(t)})}{\partial k_t} = \frac{v_l}{f_n}$$
$$\Rightarrow v_m = \frac{z}{R_n}.\frac{1}{Cov_t} \qquad (15)$$
$$\dot{V} = -\dot{R} - d(CFR_t) = 0 \Rightarrow \dot{R} = -d(CFR_t)$$

$$\frac{\partial W(a_t, k_{(t-1)})}{\partial m_t} = \frac{\partial V}{\partial l_t}\frac{\partial l_t}{\partial g}\frac{\partial g}{\partial m_t} Cov_t + \beta E_t [\frac{\partial W(a_{t+1}, k_{(t)})}{\partial a_{t+1}}.\frac{\partial a_{t+1}}{\partial m_t} + \frac{\partial W(a_{t+1}, k_{(t)})}{\partial k_t}.\frac{\partial k_t}{\partial m_t}] = 0$$
$$\Rightarrow -v_l g_m Cov_t + \beta E_t [\frac{\partial W(a_{t+1}, k_{(t)})}{\partial a_{t+1}}.\frac{1+i_t^m}{(1+\pi_{t+1})(1+n)} - \frac{\partial W(a_{t+1}, k_{(t)})}{\partial k_t}].$$
(16)

$$\frac{\partial W(a_t, k_{(t-1)})}{\partial b_t^g} = \beta E_t [\frac{\partial W(a_{t+1}, k_{(t)})}{\partial a_{t+1}}.\frac{\partial a_{t+1}}{\partial b_t^g} + \frac{\partial W(a_{t+1}, k_{(t)})}{\partial k_t}.\frac{\partial k_t}{\partial b_t^g}] = 0$$
$$\Rightarrow \beta E_t [\frac{\partial W(a_{t+1}, k_{(t)})}{\partial a_{t+1}}.\frac{1+i_t^g}{(1+\pi_{t+1})(1+n)} - \frac{\partial W(a_{t+1}, k_{(t)})}{\partial k_t}]. \qquad (17)$$

Removing, $\frac{\partial W(a_{t+1}, k_{(t)})}{\partial a_t + 1}$ in equations (16) by the equations (17) , equation (18) is obtained:

$$-v_l g_m Cov_t = \frac{i_t^g - i_t^m}{1+i_t^g} \beta E_t \frac{\partial W(a_{t+1}, k_{(t)})}{\partial k_t} \qquad (18)$$

According to equation (14), $\beta E_t \frac{\partial W(a_{t+1}, k_{(t)})}{\partial k_t} = \frac{v_l}{f_n}$. By removing $\frac{\partial W(a_{t+1}, k_{(t)})}{\partial k_t}$ from equation (18), and replace it by $\frac{v_l}{f_n}$, we can omit v_l from both side of equation (18), finally , equation (19) is extracted.

$$-g_m f_n = \frac{i_t^g - i_t^m}{1+i_t^g} \cdot \frac{1}{Cov_t} \tag{19}$$

The left side is the opportunity cost for holding additional money in the shopping time model. This is the value of transaction time saved by additional holding money. Health discretionary interventions due to change (increase) in CFR, cause an increase in Cov_t. This effect decreases opportunity cost on holding additional money and increases demand for money. Certainly, any factor that increases the Cov_t , increases the demand for money. For example, a decrease in the household's immunity system, or decreasing the trust in planners (or increasing the household probability of not acceptance of a health policy) would increase Cov_t and increase demand for money.

4.5. Numerical Analysis

We know that in (19), $g_m < 0$ then we define $-g_m f_n = V_m \geq 0$. According to the loanable funds theory, "The discount rate is the interest rate at which Federal Reserve or central banks lend reserves to depository institutions, primarily to enable these institutions to meet their reserve requirements. Market interest rate are determined by' the intersection of the demand and supply of credit "(Thornton 1982, 3). Therefore, whenever a monetary authority feels that the market is in trouble and there is a need to quickly intervene in the market through interest rates, it starts changing the discount rate. According to the theory of loanable funds theory, there is a positive relation between [1]discount rate and interest on money(as market interest rate) and also discount rate has an inverse effect on the price of government bond and its yield.We can define a relation between discount rate, bond yield, and interest on money as (20):

$$\frac{i_t^g - i_t^m}{1+i_t^g} = \frac{z}{R_n}. \tag{20}$$

z is a parameter and R is discount rate. Now, I can rewrite equation (19):

$v_m = \frac{z}{R_n}.\frac{1}{Cov_t}$. And if I take "Ln" from both side:

$$Ln(v_m) = \ln(z) - \ln(R_n) - Ln(Cov_t) \tag{21}$$

We also know that $Cov_t = e^{CFR_t}[pr + \alpha(1-pr)]$. I rewrite it by "Ln" form:

$\ln Cov_t = CFR_t + \ln[pr + \alpha(1-pr)]$

By replacing the above equation in Equation (21):

$Ln(v_m) = \ln(z) - \ln(R_n) - CFR - \ln[pr + \alpha(1-pr)]$.

With differntialization from both sides and in [2]steady state, in which only CFR_t varies:

$$\dot{V} = -\dot{R} - d(CFR_t) = 0 \Rightarrow \dot{R} = -d(CFR_t) \tag{22}$$

This condition says that any banking discount rate growth in COVID-19 economy, depends on negative variation of CFR_t .

I give an example. In Jan 2020, in the USA, the discount rate was2.25 and $CFR_t = 0$

In Feb 2020, in the USA, the discount rate was also 2.25 and $CFR_t = 1.47$. Was the announced discount rate in Feb optimal? According to the

1. Some countries such as Indonesia use reverse repo instead of the discount rate.
2. This condition is consistent with Resi (2007). He mentions that a steady-state, does not require money or interest rates have to be constant. (Resi, 2007, 132).

result, it was not. I use discount rates in February and January by R_{fe}, R_{jun}. Discount rate growth in Feb is $\frac{R_{fe}-R_{jun}}{R_{jun}}$.

d($Cfr_t) = 1.47 - 0$. Now, $\frac{R_{fe}-R_{jun}}{R_{jun}}$=-$(1.47 - o) \Rightarrow R_{fe} = 2.22$. In the table (4) this rule is computed for all 15 GDP countries for each month of 2020.

Table 4. Optimal discount rate during COVID 19 for Top 15 GDP of the world

Month	USA			China			Japan		
	Announced	CFR	Optimal	Announced	CFR	Optimal	Announced	CFR	Optimal
Ja	2.25	0.00	2.25	2.9	2.20	2.84	0.1	0.00	0.10
Fe	2.25	1.47	2.22	2.9	3.84	2.67	0.3	2.07	0.10
Mar	0.25	2.57	2.13	2.9	25.55	1.88	0.3	2.68	0.09
App	0.25	6.55	1.93	2.9	100.99	-0.50	0.3	3.13	0.09
May	0.25	5.82	1.69	2.9	0.72	0.01	0.3	16.68	0.07
Jun	0.25	2.40	1.56	2.9	0.00	0.01	0.3	4.65	0.06
Jul	0.25	1.33	1.50	2.9	0.00	0.01	0.3	0.22	0.05
Aug	0.25	2.03	1.45	2.9	0.00	0.01	0.3	0.83	0.05
Sep	0.25	1.96	1.39	2.9	0.00	0.01	0.3	1.81	0.05
Oct	0.25	1.25	1.34	2.9	0.00	0.01	0.3	1.10	0.05
Nov	0.25	0.89	1.32	2.9	0.00	0.01	0.3	0.79	0.05
Dec	0.25	1.23	1.29	2.9	0.00	0.01	0.3	1.55	0.05

Month	Germany			UK			India		
	Announced	CFR	Optimal	Announced	CFR	Optimal	Announced	CFR	Optimal
Ja	0	0.00	0.00	0.75	0.00	0.75	5.4	0.00	5.40
Fe	0	0.00	0.00	0.75	0.00	0.75	5.4	0.00	5.40
Mar	0	1.08	-1.08	0.1	10.68	0.09	4.65	2.51	5.26
App	0	6.41	-1.14	0.1	18.34	0.07	4.65	3.21	4.96
May	0	2.99	-1.10	0.1	11.58	0.07	4.25	2.34	4.69
Jun	0	6.08	-1.13	0.1	8.63	0.08	4.25	2.11	4.48
Jul	0	2.74	-1.09	0.1	4.01	0.09	4.25	1.08	4.34
Aug	0	4.68	-1.12	0.1	0.96	0.10	4.25	0.80	4.25
Sep	0	2.02	-1.09	0.1	0.50	0.10	4.25	0.53	4.20
Oct	0	1.98	-1.09	0.1	0.81	0.10	4.25	0.29	4.16
Nov	0	1.36	-1.08	0.1	1.93	0.10	4.25	0.16	4.14
Dec	0	2.36	-1.09	0.1	1.76	0.10	4.25	0.11	4.13

Month	France			Italy			Canada		
	Announced	CFR	Optimal	Announced	CFR	Optimal	Announced	CFR	Optimal
Ja	0	0.00	0.00	0	0.00	0.00	1.75	0.00	1.75
Fe	0	2.13	-2.13	0	2.57	-2.57	1.75	0.00	1.75
Mar	0	7.44	-2.24	0	11.88	-2.81	0.25	1.18	1.73
App	0	28.39	-2.71	0	15.62	-2.91	0.25	6.91	1.59
May	0	21.42	-2.52	0	19.86	-3.04	0.25	10.90	1.31
Jun	0	7.86	-2.18	0	18.59	-3.00	0.25	9.78	1.04
Jul	0	2.06	-2.06	0	5.39	-2.60	0.25	2.84	0.91
Aug	0	0.42	-2.02	0	0.87	-2.49	0.25	1.51	0.87
Sep	0	0.50	-2.02	0	0.90	-2.49	0.25	0.57	0.85
Oct	0	0.64	-2.03	0	0.74	-2.48	0.25	1.07	0.83
Nov	0	2.03	-2.05	0	1.83	-2.51	0.25	1.41	0.81
Dec	0	3.14	-2.08	0	3.66	-2.56	0.25	1.71	0.79
Month	**South Korea**			**Russia**			**Brazil**		
	Announced	**CFR**	**Optimal**	**Announced**	**CFR**	**Optimal**	**Announced**	**CFR**	**Optimal**
Ja	0.5	0.00	0.50	6.25	0.00	6.25	10.66	0.00	10.66
Fe	0.25	0.54	0.50	6	0.73	6.20	10.44	0.00	10.66
Mar	0.25	2.19	0.48	6	1.01	6.10	10.19	3.52	10.29
App	0.25	8.68	0.43	5.5	1.21	5.96	9.87	7.15	9.19
May	0.25	3.40	0.38	5.5	1.91	5.77	9.19	5.38	8.04
Jun	0.25	0.88	0.36	4.5	2.42	5.52	8.73	3.12	7.35
Jul	0.25	1.26	0.36	4.25	2.14	5.27	8.28	1.94	6.98
Aug	0.25	0.39	0.35	4.25	1.91	5.06	8.05	1.31	6.75
Sep	0.25	2.33	0.34	4.25	1.72	4.88	8.01	0.86	6.61
Oct	0.25	1.89	0.33	4.25	1.78	4.71	8.01	0.54	6.51
Nov	0.25	0.81	0.32	4.25	1.92	4.53	8.01	0.39	6.45
Dec	0.25	1.41	0.31	4.25	0.00	4.44	8.01	0.51	6.40
Month	**Australia**			**Spain**			**Indonesia**		
	Announced	**CFR**	**Optimal**	**Announced**	**CFR**	**Optimal**	**Announced**	**CFR**	**Optimal**
Ja	0.75	0.00	0.75	0	0.00	0.00	5	0.00	5.00
Fe	0.75	0.00	0.75	0	0.00	0.00	4.75	0.00	5.00
Mar	0.25	0.42	0.75	0	5.38	-5.38	4.5	8.63	4.57
App	0.25	3.62	0.72	0	25.08	-6.44	4.5	7.70	3.82
May	0.25	2.27	0.67	0	24.84	-6.42	4.5	4.81	3.34
Jun	0.25	0.31	0.66	0	3.31	-5.04	4.25	3.21	3.08
Jul	0.25	1.03	0.65	0	0.17	-4.88	4	3.27	2.88
Aug	0.25	5.15	0.61	0	0.33	-4.89	4	2.16	2.72
Sep	0.25	17.57	0.47	0	0.91	-4.92	4	1.83	2.61
Oct	0.25	4.10	0.37	0	0.91	-4.92	4	1.33	2.53
Nov	0.1	0.32	0.35	0	2.08	-4.98	3.75	1.02	2.47
Dec	0.1	0.20	0.35	0	1.95	-4.97	3.75	1.20	2.42

Source: Research finding

4.6. Discussion

I discuss the results in two sections: "Double time inconsistency effects", and "Flexibility in changing discount rate".

4.6.1. Double time inconsistency effects

According to equation (19), the opportunity cost of holding additional money depends on monetary authority and health authority decisions. The left side of this equation has two parts. The first part is $\frac{i_t^g - i_t^m}{1+i_t^g}$, that is influenced by the discretionary changing discount rate of the monetary authority. Another part is Cov_t . In this part, health restrictions are influenced by health authority decisions. Therefore, there are two channels for changing the demand for money in the COVID-19 economy. One is a discretionary monetary authority and the second is discretionary health authority. These two kinds of discretionary policies make double time inconsistency in an economy.

4.6.2. Flexibility in changing the discount rate

Non-union countries have been reacted faster and more flexibly than (GIFS) to change their discount rates in response to the COVID-19 shock. For Example [1]FOMC in the USA decreases the discount rate suddenly from 2.25 in Feb2020 to 0.25 in Mar 2020. British, Canada, and Australia changes the discount rate twice in March 2020. But, according to the results of the paper, the four EU members (GIFS) must have different discount rates because of the different optimal values. This inflexibility due to the union policy of the European Central Bank increases the rate and time of non-optimality in these countries.

1. Federal open market committee

5. Conclusions

The discretionary interventions of the health authority lead to the formation of short-run health policies. These policies provide two choices for people to accept or reject. People with a certain probability accept or reject it based on the level of trust in the health authority. Acceptance of policies increases vertical queues and non-acceptance increases horizontal queues. The length of time in the horizontal queue (hospitalization period) depends on the degree of immunity of the individual. Therefore, the time elapsed in the horizontal and vertical lines cannot be equal. Reducing leisure time due to vertical and horizontal queues creates the need for a tool to compensate for this disutility for a representative household in the shopping time model. So the demand for money to get out of the queues is formed. This getting out money, increases demand for money due to the uncertainty of COVID_19 and based on the precautionary effect of demand for money.

Therefore, by the intervention of the health authority in the economy, the demand for money is not only affected by conventional factors such as interest on money and the yield of government bonds but also depends on the level of household's trust in the health authority, personal immunity and, CFR_t. An optimal conditional monetary policy rule, assuming that the health authority imposes health restrictions solely on the basis of CFR_t, is a rule in which discount rate growth(and consequently interest on money and government bond yield) in COVID-19 economy, depends on the negative variation of CFR_t. This rule can also be applied to countries such as the Islamic Republic of Iran, that have not applied the policy of changing the discount and rate during COVID-19.

Funding

This study received no financial support from any organization.

Authors' contributions

All authors had contribution in preparing this paper.

Conflicts of interest

The author declare no conflict of interest

References

Alfaso, V, Ercolano, S. (2020). The efficiency of lockdown against COVID-19: a cross-country panel analysis. *Journal of Applied Health Economics and Health Policy*; 18(4); 509–517

Alvarez, F.E., Argente, D., & Lippi, F. (2021). A Simple Planning Problem for COVID-19 Lockdown. American economic review; 3(3): 367-82

Baldwin, R. (2020). Dimauro, W. M. (2020). Economics in the Time of COVID-19. *Centre for Economic Policy Research.*

Barro, R.J., & Gordon, D.B. (1983a). Rules, Discretion and Reputation, In a Model of Monetary Policy, *Journal of Monetary Economics*; 12: 101-121.

Barro, R.J., &Gordon, D.B. (1983b). A positive theory of monetary policy in a natural rate model, *Journal of Political Economy*. Journal of Political Economy; 91(40): 589-610.

Barro, R.J. (1986). Reputation in a model of monetary policy with incomplete information. *Journal of Monetary Economics*; 17: 3-20.

Barro, R.J., & Ursúa, J. F., & Weng, Joanna. (2020). The Coronavirus and the Great Influenza Epidemic Lessons from the “Spanish Flu” for the Coronavirus’s Potential Effects on Mortality and Economic Activity. Working Paper 26866, *National Bureau of Economic Research.*

Barua, S. (2021).Understanding Coronanomics: The Economic Implications of the Coronavirus (COVID-19) Pandemic. *The Journal of Developing Areas*; 55(3): 435-450.

Bastanifar, I., Vaez, B, M., & Dallali, R., & Bakhshi, R. (2013). Alternative Conditions to Time Inconsistency Equilibrium of an International Monetary Policy. *International Economics Studies*; 42(1): 57-67.

Beck, T. (2020). Finance in the times of coronavirus. In Baldwin, R. and di Mauro, B.W. (Eds), Economics in the Time of COVID-19, Centre for Economic Policy Research.73-77.

Cecchetti, S. (2020). Contagion: Bank runs and COVID-19. In Baldwin, R. and di Mauro, B.W. (Eds), Economics in the Time of COVID-19, *Centre for Economic Policy Research: London*; 77-81.

Chudic, A., Hashempesaran, M, &Rebucci. A. (2021). COVID-19 Time-Varying Reproduction Numbers Worldwide: An Empirical Analysis of Mandatory and Voluntary Social Distancing. Johns Hopkins University - Carey Business School; *Centre for Economic Policy Research,* Working Papers w 28269.

Disemadi, H, S., & Handika, D.O. (2020). Community compliance with the covid-19 protocol hygiene policy in Klaten Regency, Indonesia. *Legality, Jurnal Ilmiah Hukum*; 28(2): 121-133.

Fornaro, L., & Wolf, M. (2020). Covid-19 Coronavirus and Macroeconomic Policy. Working Papers 1713, *European Research Council under the European Union's Horizon.*

Gillman, M. (2009). Inflation theory in Economics. Welfare, Velocity, growth and business cycle: *Routledge.*

Gillman, M. (2020). The welfare cost of inflation with banking time. The B.E. *Journal of Macroeconomics*; 20(1):1-20. DOI: 10.1515/bejm-2018-0059

Harrington, R. A. (2008) Encyclopedia of Epidemiology. https://www.britannica.com/science/case-fatality-rate.

Ivorraa, B., Fernandez, M.R., Vela-Pérez, M., & Ramos, A.M. (2020). Mathematical modeling of the spread of the coronavirus disease 2019 (COVID-19) taking into account the undetected infections. The case of

China, communications in nonlinear science and numerical simulation. 88. 105303. DOI: 10.1016/j.cnsns.2020.105303.

Kermac, W. O., Mckendrick, A .G. (1927). A Contribution to the Mathematical Theory of Epidemics. Proceedings of the Royal Society. 115 (772): 700–721.

Kendall, D. G. (1956). Deterministic and stochastic epidemics in closed populations. *Proceedings of the Third Berkeley Symposium on Mathematical Statistics and Probability*: Contributions to Biology and Problems of Health 4: 149–165.

Keyes, J.M. (1936). General Theory of Employment, Interest and Money, *New York*.

Kydland, F, K., Prescott, E.C. (1977). Rules Rather Than Discretion, the Inconsistency of Optimal Plans, *Political Economy*; 85(3): 473-492.

Lucas, R. J., & Stokey, N. (1983). Optimal fiscal and monetary policy in an economy without capital. *Journal of Monetary Economics*; 12: 55–93.

Lucas, R. J. (2000). Inflation and welfare. Journal of the econometric society; 68(2): 247-274.

Mankiew, G.M. (2003).Principle of Macroeconomics, *Third Edition. Southwester*, Thomson.

Mishkin. F, S. (2004). The economics of money, banking, and financial markets, seventh edition, *The Addison-Wesley Series in Economics*.

Nivette, A., Ribeaud, D., Murray, A., Steinhoff, A., Bechtiger, L., Hepp, U., Shanahan, L., & Eisner, M. (2021). Non-compliance with COVID-19-related public health measures among young adults in Switzerland: Insights from a longitudinal cohort study. *Social science and medicine*, 268; 113370. DOI: 10.1016/j.socscimed.2020.113370.

Porta, M. (2014). A Dictionary of Epidemiology, sixth edition. *New York: Oxford University Press*.

Resi, R. (2007). The analytics of monetary non-neutrality in the Sidrauski model. *Economics Letters*; 97(1): 129–135.

Ross, R. (1916). An application of the theory of probabilities to the study of a priori pathometry. Part I. *Proceedings of the Royal Society of London. Series* A, Containing Papers of a Mathematical and Physical Character; 92; 204-230. doi:10.1098/rspa.1916.0007.

Ross, R., &Hudson, H. (1917). An application of the theory of probabilities to the study of a priori pathometry.—Part II. *Proceedings of the Royal Society of London.* Series A, Containing Papers of a Mathematical and Physical Character; 93; 212- 225. doi:10.1098/rspa.1917.0014.

Stiglitz, J. (2021). Lessons from Covid-19 and Trump for Theory and Policy. *Policy Modeling*, 43(4):749-760 .
DOI: 10.1016/j.jpolmod.2021.02.004.

Tabellinin, G. (2005). Finn Kydland and Edward Prescott's Contribution to the Theory of Macroeconomic Policy. *Scandinavian Journal of Economics*, 107(2); 203-216. DOI: 10.1111/j.1467-9442.2005. 00404.x

Thornton, D.L. (1982). The Discount Rate and Market Interest Rates: What's the Connection? *Federal bank of St.Louis.*

Umesh, U. N., Keity, L., Carl, S. (1989). Shopping time of the time-Sensitive Consumer. *Decision science* 20(4): 715-729.
https://doi.org/10.1111/j.1540-5915.1989.tb01415.x

Walsh, C, E. (2017). Monetary Theory and Policy, The fourth edition. *MIT Press.*

www.fredhelp.stlouisfed.org

www.https://data.imf.org.

https://data.oecd.org/money/narrow-money-m1.htm#indicator-chart).

www.cebm.net/covid-19/global-covid-19-case-fatality-rates).

www.globalpeoservices.com

www.who.int/publications/i/item/WHO-2019-nCoV-Sci_Brief- Natural_ immunity-2021.1

www.worldometers.info/world-population

www.worldometers.info/coronavirus

https://tradingeconomics.com/indonesia/interest-rate.
https://ycharts.com/indicators/bank_of_japan_basic_discount_rate_daily.
https://www.global-rates.com.