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Can Central Bank Mitigate the Effects of the COVID-19 Pandemic on the Macroeconomy?

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ABSTRACT

Facing with the enormous economic loss resulting from the unexpected outburst of the COVID-19 pandemic, central banks around the world began to show a great activeness and implement numerous monetary policies to help mitigate the negative shocks and recover the economy. This paper aims at investigating the impact of the COVID-19 pandemic on the macroeconomy and whether central bank activeness have helped mitigate the negative shock of the COVID-19. Using the panel fixed effects model and monthly data of 38 countries from January 2020 to June 2021, this paper finds that the COVID-19 pandemic has increased inflation and unemployment apparently. More importantly, central bank activeness has a positive effect on reducing the growing pressure from the COVID-19 on inflation, while it cannot mitigate the shock of the COVID-19 on unemployment rate. Specially, government others measure, including containment and health, and stringency policies, have little effect in mitigating the negative impact of the pandemic on inflation and unemployment. Our findings suggest that the central bank activeness have heterogeneous effects on different macroeconomic indicators, and cannot mitigate the hurts of the COVID-19 pandemic for all macro indicators during the pandemic.

KEYWORDS
COVID-19; central bank activeness; inflation; unemployment

JEL
I18; E52; E58

1. Introduction

The COVID-19 pandemic is considered as the most devastating shock to the global economic system at 2020 (Barua 2020; Chang, Feng, and Zheng 2021; Dave et al. 2020; Wang et al. 2021). According to rough estimates, its fatality rate is much higher than that of seasonal flu, up to 30 times, and its infectiousness is at least 10 times that of SARS (WHO 2021; Wilder-Smith, Chiew, and Lee 2020; Wilson et al. 2020). The pandemic not only exposed the weaknesses of global health systems, but also brought significant economic stagnation (Abedi et al. 2021; Bambra et al. 2020; Brotherhood et al. 2020). The pandemic has created growing uncertainties with respect to job prospects, economic recovery, financial stability, incomes and social development (Alvarez, David, and Francesco 2020; Béland, Brodeur, and Wright 2020; Maria et al. 2020; Pak et al. 2020).

Specifically, the COVID-19 pandemic led to a huge shock on the supply and demand. That is, the pandemic not only reduces the ability of people to work and the production of enterprises, but also reduces people's desire for consumption and the incentive and possibility of enterprise investment (Bénassy-Quéré et al. 2020; Furman 2020; Gopinath 2020). More importantly, the pandemic has brought about a series of crises at an unimaginable speed, including inflation and unemployment (Baldwin and Weder Di Mauro 2020). Terrie et al. (2021)estimated that within 3–6 months, the US GDP will fall by 20.3%, and 22.4% of the US population will be unemployed, and

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the second wave of the epidemic will bring about double loss. Ababulgu and Wana (2021) state that the Ethiopian economy reflects to a certain extent the real economic dilemmas faced by Africa under the influence of the COVID-19 pandemic. At the beginning of 2021, Ethiopia's overall inflation rate was 23%, food inflation rate was 26%, and government debt accounted for more than 55% of GDP.

To alleviate the negative shock of the COVID-19 pandemic, governments begin to enact and implement numerous measures (Chang, Feng, and Zheng 2021). These measures include school closures, workplace closures, testing policy, cancellation of public events, extent of contact tracing, restrictions on public gatherings, international travel controls, closures of public transport, face coverings, stay-at-home requirements, restrictions on internal movements, public information campaigns, and vaccine policy etc. Researchers have estimated the economic and life losses that the pandemic may bring, and believe that it is necessary to analyze the economic consequences of the measures taken to determine the best mitigation measures (Atkeson 2020; Barro, José, and Joanna 2020).

At the same time, central banks have attempted to play a significant role in mitigating the effects of the COVID-19 pandemic through devising appropriate monetary policies. These policies cover interest rate policy, reserve policy, foreign exchange policy, lending operations policy, asset purchases policy and other policy. Mosser (2020) notes that central bank actions are likely to exhibit a positive effect on the financial market and the real economy, but central bank policy can only indirectly address the core economic policy challenges of the crisis. Rebucci, Hartley, and Jiménez (2021) show that compared to emerging economies, a central bank's quantitative easing policy has a more intuitive effect on advanced economies during the COVID-19 pandemic. In addition, the importance of central bank independence (Elgina et al. 2021) and swap lines (Aizenman, Ito, and Pasricha 2021; Bahaj and Reis 2020) during the pandemic has also attracted researchers' attention.

However, a few attentions are pay in the role of monetary policies during the pandemic time. Whether the proactive actions of the central bank can alleviate the impact of the pandemic on the economy remains to be studied.

In this context, this paper aims to investigate the impact of the COVID-19 pandemic on the macroeconomy and whether the central bank activeness is able to mitigate the negative impact of COVID-19. Using the panel fixed effects model and monthly data from 38 countries from January 2020 to June 2021, this paper explores the impact of the COVID-19 pandemic on inflation and unemployment rates. At the same time, we included the government's policy response to COVID-19 in the study, and distinguished the role of government response and central bank activeness in mitigating the adverse economic impact of the pandemic. In addition, we also chose the dynamic panel model to consider the persistence of inflation and unemployment, eliminate country-specific fixed effects, and address possible endogenous problem through the inclusion of higher-order lagged dependent variables, for providing more reliable results. Therefore, this article aims to fill the gaps in the literature by focusing on the role and impact of central bank activeness on specific economic indicators during the COVID-19 pandemic.

In the COVID-19 pandemic, government measures including closures and travel bans have directly changed the production expectations of enterprises and household consumption expectations (that is, market supply and demand expectations), leading to a decline in production and consumption. Public health measures aimed at slowing the spread of the pandemic (such as workplace closure) have indirectly and temporarily reduced employment since people have to stay at home or take care of relatives who have already been infected. Studies have pointed out that families living in counties where the lockdown was implemented earlier are expected to increase their unemployment rate by 13% in 12 months, and it is expected that the unemployment rate will continue to rise in the next 3 to 5 years (Olivier, Yuriy, and Michael 2020). They also expect future inflation rates to fall and uncertainty to rise, and mortgage interest rates are expected to be lower in the next 10 years. They have already withdrawn from overseas stock markets and turned to liquid savings (Olivier, Yuriy, and

Michael 2020). In addition, the quarantine measures for close contacts will double the impact of the COVID-19 pandemic on production and employment. The simpler and more direct restrictive policies are easier to save people's lives, but they also increase the severity of the recession (Eichenbaum, Sergio, and Mathias 2020). The "Swedish solution" that allows the pandemic to break out without government intervention and allows agents to shift their consumption behavior to a relatively safe sector, although it alleviates the economic and health crisis, it still means many deaths and substantial economic activity decline (Dirk et al. 2020).

In the financial markets and energy markets, which are closely related to the macroeconomy, the pandemic has also brought huge negative effect (Song et al. 2021; Feng et al. 2021a; Chen et al. 2019; Fu et al. 2020; Wen et al. 2021; Wen et al. 2021). In the financial markets, the overall social distancing and lockdown measures announced by governments have had a direct negative impact and lowered the returns in the stock market (Ashraf 2020) and have had the same negative impact on stock prices in the energy industry, including solar energy firms (Wang et al. 2020). In terms of specific measures, government policy responses of canceling public events, shutting down workplaces, providing income support, restricting public gatherings and international travel, and implementing fiscal measures can increase stock market returns (Chang, Feng, and Zheng 2021). In addition, the COVID-19 pandemic has raised the volatility of exchange rates, and government response measures can curb such volatility (Feng et al. 2021b; Yang et al. 2021).

Many researchers have provided their best policy solutions. Callum et al. (2020)believe that the carrying capacity of the public health system is very limited, and the best mitigation policy during the pandemic is to maintain social distancing and work from home. Keynesian economics researchers point out that demand may indeed overreact to supply shocks, leading to a recession of insufficient demand. Therefore, the best policy to deal with the COVID-19 pandemic is to implement a loose monetary policy and provide adequate social insurance (Veronica et al. 2020). Although government administrative measures are vital, they cannot completely alleviate the economic recession. A comprehensive response from monetary policy, fiscal policy, and public health policy is the key to economic recovery (Warwick and Roshen 2021).

According to the Taylor (1993) rule, the level of policy interest rate closely relates to inflation's deviation from the target and the potential for output deviation (output gap). Central banks are bound to take forward-looking measures to avoid an economic recession. As one conventional method of central banks, monetary policy is considered to be an important tool for seeking systematic and effective strategic decision-making during the uncertain environment of COVID-19 (Nicholas 2021). Following the quantity theory of money, currency growth is the main cause of inflation, the amount of money available in the economy determines the value of money. Therefore, the increase in output and employment caused by expansionary monetary policies usually means rising prices and wages, and ultimately leading to inflation. Conversely, tightening monetary policies that curb output and employment usually reduce inflation (Friedman 2020). As a matter of fact, traditional fiscal and monetary policies may not work as usual in the special context of this pandemic. The magnifying negative effect of the pandemic on industry may cause a large number of companies to withdraw (Guerrieri et al. 2020). In the short term, the economic impact of the pandemic depends critically on whether or not monetary policy accommodates the drop in the natural rate of interest (Dietrich et al. 2020). One overlooked fact is that monetary policy may have different effects in dealing with inflation and unemployment. Orkun, Elif, and Deniz (2021) point out during the COVID-19 pandemic that the increase in money supply has a greater pass-through effect on the unemployment rate.

The supply shock caused by the pandemic is generally considered to be a labor supply shock. Mortality, infection rates and caring for affected family members will all lead to a reduction in the labor supply. In countries that have adopted social distancing measures, the economic impact of such measures will be far greater than the direct impact of mortality and infection rates (McKibbin and Fernando 2020). The pandemic also strongly affects consumer spending patterns. For example, consumers may reduce the demand for products and services that are in close contact with others to avoid the risk of frequent exposure to the virus. This is also why in the early stages of the outbreak, the demand for the retail industry increased sharply due to stockpiling behavior (Baker et al. 2020). In order to compare supply and shock demand, Rio-Chanona et al. (2020)consider the following thought experiment. After adopting public health measures, workers in industry *i* can only produce 70% of the original output, so the total output of industry *i* can only produce 70% of the output before the crisis. If consumer demand is reduced to 10% before the pandemic, the industry will only produce 10%. However, if consumers still have 80% of the demand before the epidemic, then the industry will not be able to meet the demand, but will produce all the products they can produce, that is, 70%. In other words, under the direct impact of the pandemic, supply capacity will determine the direction of the market to a greater extent than demand. Therefore, this paper also focuses on the supply side.

To anticipate the results, we find that central bank activeness has a positive effect on reducing the growing pressure from the COVID-19 on inflation, while it cannot mitigate the shock of the COVID-19 on unemployment rate. Specially, government others measure, including containment and health, and stringency policies, have little effect in mitigating the negative impact of the pandemic on inflation and unemployment. Our research has contributed to the existing literature in several ways. First, we are the first to place central bank activeness under the overall impact of the COVID-19 pandemic and examine its effect on alleviating downward pressure on the economy. This paper uses monthly panel data from 38 countries from January 2020 to June 2021 to study the impact of the central bank's monetary policy announcements in response to the COVID-19 pandemic on inflation and unemployment, complementing the studies related to the consequences of policy response to the COVID-19. Secondly, we select the stringency index, containment and health index in the government response index constructed by Hale et al. (2020)and others to distinguish the role of government response and monetary policy in the pandemic. Accordingly, our results related to monetary policies can be distinguished with government response actions. Third, our findings show opposite effect of monetary policies to inflation and employment, which provide valuable information for issuing monetary policies. This article discusses the role of central bank activeness in mitigating the impact of the COVID-19 pandemic from the perspective of a global perspective and multi-dimensional policy effects. The results suggest that monetary policies can lower inflation and increase unemployment rate during the pandemic. As a result, our results help policy makers to set up appropriate policy packages to cushion the negative shock from the pandemic.

The remainder of this paper proceeds as follows. Section 2 introduces the empirical model, variable definition, and data source. Section 3 reports empirical results. Section 4 offers the main conclusion and policy implications.

2. Methodology

2.1. The Empirical Model

To explore the impact of the COVID-19 pandemic on the macroeconomy and whether central bank activeness have helped mitigate the negative shock of the COVID-19, this paper utilizes a panel fixed effects model setting as follows.

$$\begin{aligned} Inflation_{it}(Unemployment_{it}) = c + \beta_1 COVID_{it} + \beta_2 Export_{it} + \beta_3 Import_{it} + \beta_4 GDP_{it} \\ + \beta_5 Containment_{it} + \beta_6 Stringency_{it} + \lambda_i + \alpha_t + \varepsilon_{it} \end{aligned} \tag{1}$$

$$\begin{aligned} Inflation_{it} = c + \alpha_1 COVID_{it} + \alpha_2 CBA_{it} + \alpha_3 COVID_{it} * CBA_{it} + \alpha_4 Export_{it} + \alpha_5 Import_{it} + \alpha_6 GDP_{it} \\ + \alpha_7 Containment_{it} + \alpha_8 Stringency_{it} + \lambda_i + \alpha_t + \varepsilon_{it} \end{aligned} \tag{2}$$

where $Inflation_{it}$ represents the consumer price index growth in country *i* at month *t*; $Unemployment_{it}$ represents the unemployment rate in country *i* at month *t*; $COVID_{it}$ includes newly confirmed cases and deaths in country *i* at month *t*; CBA_{it} denotes the number of monetary policy announcements issued by the central bank in country i at month t; $COVID_{it} * CBA_{it}$ denotes the interaction term between newly confirmed cases (death) and the total number of monetary policy announcements of country i in month t; $export_{it}$, $import_{it}$, GDP_{it}, $Containment_{it}$ and $Stringency_{it}$ are control variables that may affect inflation and unemployment rate.

2.2. Variables' Definitions and Data Sources

It is well recognized that inflation and unemployment are two important indicators for measuring the macroeconomy performance. Higher inflation and lower unemployment generally reflect good macroeconomic conditions (Tobin 1995). Therefore, this article uses inflation and unemployment (proxy by monthly consumer prices index and unemployment rate) as the dependent variable to proxy the macroeconomy conditions.

Our core explanatory variables are *Newcase* and *Newdeath*, which are used to measure the severity of the COVID-19 pandemic (Chang, Feng, and Zheng 2021; Wang, Chen, and Chang 2020). The source of *Newcase* and *Newdeath* indexes are from the website https://ourworldindata.org/covid-death. This website reports daily cases and deaths of the COVID-19 in every country. To match the monthly macroeconomy variables, we aggregate daily data of the COVID-19 to monthly data and use the natural logarithm of the total number of new added cases (*Newcase*) and new deaths (*Newdeath*) in the empirical analysis.

Another main explanatory variable is central bank activeness (*CBA*), which is measured by the monthly number of monetary policy announcements issued by the central banks of the sample countries.[1] According to the database constructed by Carlos et al. (2021), monetary policy announcements are classified under five types of tools: interest rate measures, asset purchase programs, reserve policies, foreign exchange operations and lending operations. We use this information to describe the strength of the central bank's actions in the market. The greater the total amount of monetary policy announced each month, the greater the central bank activeness.

We also include the government response to the COVID-19 pandemic in the empirical model to further test whether the government's response will help central banks to mitigate the negative impact of the pandemic on inflation and unemployment. We consider two policy indices of government response, namely stringency index and containment and health index. The data of government response index constructed by Hale et al. (2020) is from Oxford COVID-19 Government Response Tracker (OxCGRT) database (Hannah et al. 2020). There are different metrics used to calculate these indices. For example, school closures, workplace closures and other seven metrics are used for stringency index, while cancellation of public events, closures of public transport and other eleven metrics are used for containment and health index.

A large number of studies have confirmed that imports and exports (Dexter, Levi, and Nault 2005; Gabriel, Julien, and Hans 2011; Lim and Papi 1997) and GDP (Muhammad and Raza 2013; Shiblee 2009) are important factors affecting inflation and unemployment. We also consider the availability of monthly data when selecting control variables. For example, although current account balance can also effectively reflect a country's macroeconomic conditions, it is usually published in quarterly data, and so it is not selected. Thus, this article uses import, export and GDP as the control variables to enhance the validity. The variables imports and exports are measured by the ratio of imports and exports monthly value to the nominal GDP. The variable GDP is measured by the logarithm of the nominal GDP. Since the main explanatory variables and explained variables in this article are presented in the form of monthly data, due to the availability of data, the import and export data uses monthly data published by various countries (in USD) instead of current account balance. Table 1 presents variable definitions and sources of our data.

Our data sources are reported as follows. The data of inflation, unemployment rate, export, import and GDP, are from the CEIC database. Data on government response is from the Oxford COVID-19 Government Response Tracker (Ox-CGRT) database. The data of daily confirmed cases and deaths of the COVID-19 pandemic are obtained from the website https://ourworldindata.org/

Table 1. Variable definitions and data sources.

Variable	Definition	Source
Inflation	Consumer Prices Index Growth	CEIC Database
Unemployment	Unemployment Rate	CEIC Database
Newcase	Logarithm of New Case per month	Our World in Data
Newdeath	Logarithm of New Death per month	Our World in Data
CBA	Number of Monetary Policy Announcements	Carlos et al. (2021)
Export	Total Export Goods/Nominal GDP in USD	CEIC Database
Import	Total Import Goods/Nominal GDP in USD	CEIC Database
GDP	Logarithm of Nominal GDP in USD	CEIC Database
Containment	Monthly Average Containment and Health Index	Our World in Data
Stringency	Monthly Average Government Stringency Index	Our World in Data

explorers/coronavirus-data-explorer, then we aggregate them into monthly data. Based on the work of Carlos et al. (2021), we compiled data files on monetary policy announcements of central bank. After merging these three datasets, our final sample includes 38 countries from January 2020 to June 2021. The final sample is unbalanced because there are a lot of missing values.

2.3. Descriptive Statistics

Table 2 reported the results of descriptive statistics for the main variables. As we can see, the average inflation is 3.425, indicating that most of the sample countries are in an inflationary state. The minimum value of inflation is −3.440 and the maximum value is 52.856, indicating the huge fluctuation of inflation caused by the pandemic. The average unemployment rate is 7.564, indicating that all countries have experienced a considerable degree of unemployment during the pandemic. At the same time, the minimum unemployment rate is 0.590 and the maximum is 32.600, which fully demonstrates that the COVID-19 pandemic may bring about a large negative impact on the labor market. The average value of the central bank activeness is 1.189, the minimum value is 0, and the maximum value is 25. This shows to a certain extent that central banks are trying to reduce the adverse impact of the epidemic on the macroeconomy by issuing monetary policies. Furthermore, the huge distinction between the maximum and the minimum of containment and stringency shows that the government responds to the COVID-19 pandemic spread with dramatic adjustment in the sample.

3. Empirical Results

3.1. The COVID-19 Pandemic and the Macroeconomy

Here we firstly examine the impact of the COVID-19 pandemic on the macroeconomy. Table 3 shows the regression results of the panel fixed effects model. Columns 1, 2, 5, and 6 responds to the impact of *Newcase* and *Newdeath* on inflation, respectively. Columns 5 and 6 exclude the government's response

Table 2. Descriptive statistics.

Variable	Observations	Mean	Std Dev	Min	Max
Inflation	638	3.425	7.399	−3.440	52.856
Unemployment	396	7.564	5.721	0.590	32.600
Newcase	735	9.412	3.199	0	16.014
Newdeath	734	5.344	3.198	0	11.696
CBA	735	1.189	2.463	0	25
Export	532	0.369	0.643	0.052	4.899
Import	530	0.350	0.561	0.092	4.300
GDP	533	10.930	1.310	8.580	14.454
Containment	712	58.164	18.280	0	88.569
Stringency	714	59.377	20.390	0	100

Table 3. COVID-19 and macroeconomy.

Variable	(1) Inflation	(2) Inflation	(3) Unemployment	(4) Unemployment	(5) Inflation	(6) Inflation	(7) Unemployment	(8) Unemployment
Newcase	0.092***		0.148**		0.040		0.186***	
	(2.910)		(2.358)		(1.430)		(3.355)	
Newdeath		0.127***		0.197***		0.071***		0.225***
		(4.267)		(3.327)		(2.676)		(4.282)
Export	2.638**	2.475**	4.691*	4.448*	2.703**	2.631**	5.025**	4.702*
	(2.145)	(2.034)	(1.919)	(1.835)	(2.177)	(2.131)	(2.050)	(1.937)
Import	−2.949**	−3.065**	−1.081	−1.299	−2.919**	−2.936**	−1.386	−1.608
	(−2.115)	(−2.223)	(−0.374)	(−0.455)	(−2.071)	(−2.097)	(−0.478)	(−0.563)
GDP	−2.875***	−2.684***	10.262***	10.157***	−2.350***	−2.000**	9.724***	9.721***
	(−3.257)	(−3.087)	(5.741)	(5.803)	(−2.681)	(−2.314)	(5.518)	(5.703)
Containment	−0.011	−0.010	−0.050*	−0.046*				
	(−0.760)	(−0.733)	(−1.819)	(−1.687)				
Stringency	−0.008	−0.011	0.048**	0.042*				
	(−0.702)	(−0.958)	(2.206)	(1.921)				
Constant	34.634***	32.790***	−109.012***	−107.449***	28.869***	25.114***	−103.068***	−102.568***
	(3.537)	(3.405)	(−5.441)	(−5.487)	(2.968)	(2.626)	(−5.217)	(−5.380)
Country FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Monthly FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
N	515	515	359	359	515	515	359	359
R^2	0.334	0.348	0.265	0.278	0.316	0.323	0.253	0.269

t statistics in parentheses. ***, **, and * indicate statistical significance at the 1%, 5%, and 10% levels, respectively.

indicators of containment and stringency to the pandemic. This will help us observe the impact of government response policies on inflation. Columns 3, 4, 7, and 8 show the impact of new cases and new deaths on the unemployment rate. Similarly, columns 7 and 8 exclude the role of government response indicators containment and stringency in order to observe the impact of government response policies on the unemployment rate.

We find that variables *Newcase* and *Newdeath* are both positive and statistically significant, showing that the COVID-19 pandemic has exacerbated inflation and unemployment on a global scale. This also illustrates that the COVID-19 pandemic has caused a macroeconomic recession. Our findings are consistent with the findings of Bambra et al. (2020), Pak et al. (2020), Maria et al. (2020). The variables *containment* and *stringency* have opposite effects on the unemployment rate, but both are statistically significant. The containment measure significantly reduced unemployment, while the stringency measure significantly increased unemployment. We speculate that containment, represented by measures such as vaccination and wearing masks, can help people return to work. However, stringency, represented by measures such as restrictions on gatherings and travel bans, will increase the resistance for people to return to work and is not conducive to alleviating unemployment.

After excluding the two variables *containment* and *stringency* of the government's response, the above basic conclusion has not changed. Except that the impact of variable *Newcase* on inflation is no longer significant, the pandemic still significantly increases inflation and unemployment. This may indicate that the government's response measures may not alleviate the negative macroeconomic impact of the COVID-19 effectively.

3.2. The COVID-19 Pandemic, Macroeconomy and Central Banks' Central Bank Activeness

Since the beginning of the COVID-19 pandemic, central banks of various countries have successively promulgated a number of monetary policies (Mosser 2020), including interest rate measures, asset purchase programs, reserve policies, foreign exchange operations and lending operations. These policies are undoubtedly aimed at coping with the adverse effects of COVID-19 on the macroeconomy. Therefore, this article introduces the interaction terms between the variables *Newcase* and *Newdeath* and central bank activeness to examine the role of central bank actions in the COVID-19 pandemic.

Table 4 shows the regression results of the panel fixed effects model considering central bank activeness. Columns 1, 2, 3, and 4 show the basic regression results of inflation and unemployment. Similarly, columns 5, 6, 7, and 8 are the results after excluding the variables *containment* and *stringency*. The coefficients of the variable *CBA* are 0.220 and 0.114 respectively, and they are statistically significant and positive, indicating that the activity of the central bank has a positive impact on inflation. The more active the central bank is, the more effective it is to alleviate inflation. The possible reason is that the COVID-19 pandemic has brought different instability and special characteristics to the macroeconomy, making central bank actions unable to stimulate and restore economic activities. Therefore, we should not only focus on the effect of central bank actions, but also account the interacting effect with the COVID-19 pandemic.

As we can see, the interaction term *Newcase*CBA* are statistically significant with coefficients −0.020 for *Inflation* and 0.026 for *Unemployment*. The interaction terms *Newdeath*CBA* are statistically significant with coefficients −0.016 for *Inflation* and 0.021 for *Unemployment*. It is worth noting that the interaction terms have a negative impact on inflation and a positive impact on the unemployment rate. Combining the contents of Table 3, we believe that the possible explanations for this interesting result are as follows. The sudden COVID-19 pandemic has forced companies to reduce or even stop production activities, further causing unemployment for company employees and insufficient supply for consumption goods. Furthermore, the government's response to the pandemic, such as bans on gatherings, travel bans, stay-at-home requirements, etc., has restricted companies' resumption of production and recruitment activities. As a result, the COVID-19 pandemic has led to rising inflation and increased unemployment. In order to stimulate economic recovery, central banks have

Table 4. COVID-19, central bank activeness and macroeconomy.

Variable	(1) Inflation	(2) Inflation	(3) Unemployment	(4) Unemployment	(5) Inflation	(6) Inflation	(7) Unemployment	(8) Unemployment
Newcase	0.119***		0.101		0.066**		0.145**	
	(3.603)		(1.534)		(2.251)		(2.487)	
Newdeath		0.152***		0.148**		0.094***		0.187***
		(4.852)		(2.378)		(3.308)		(3.357)
Newcase*CBA	−0.020***		0.026**		−0.020***		0.025**	
	(−2.984)		(2.186)		(−2.929)		(2.124)	
Newdeath*CBA		−0.016**		0.021**		−0.015**		0.019*
		(−2.557)		(1.992)		(−2.367)		(1.847)
CBA	0.220***	0.114**	−0.216	−0.091	0.221***	0.111**	−0.215	−0.086
	(2.966)	(2.421)	(−1.611)	(−1.089)	(2.949)	(2.316)	(−1.592)	(−1.022)
Export	2.779**	2.594**	4.491*	4.132*	2.846**	2.743**	4.845**	4.430*
	(2.276)	(2.141)	(1.855)	(1.714)	(2.307)	(2.229)	(1.993)	(1.833)
Import	−3.056**	−3.187**	−1.025	−1.060	−3.033**	−3.052**	−1.344	−1.433
	(−2.207)	(−2.321)	(−0.358)	(−0.374)	(−2.166)	(−2.187)	(−0.467)	(−0.504)
GDP	−2.818***	−2.619***	10.134***	10.004***	−2.299***	−1.924**	9.528***	9.476***
	(−3.217)	(−3.025)	(5.717)	(5.750)	(−2.641)	(−2.233)	(5.445)	(5.578)
Containment	−0.011	−0.009	−0.051*	−0.050*				
	(−0.801)	(−0.685)	(−1.879)	(−1.827)				
Stringency	−0.008	−0.012	0.051**	0.047**				
	(−0.667)	(−1.037)	(2.344)	(2.150)				
Constant	33.947***	32.060***	−107.451***	−105.719***	28.241***	24.270**	−100.776***	−99.805***
	(3.493)	(3.344)	(−5.409)	(−5.431)	(2.924)	(2.545)	(−5.136)	(−5.253)
Country FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Monthly FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
N	515	515	359	359	515	515	359	359
R^2	0.347	0.357	0.285	0.294	0.329	0.332	0.271	0.283

t statistics in parentheses. ***, **, and * indicate statistical significance at the 1%, 5%, and 10% levels, respectively.

generally taken positive actions, such as announcing monetary policies. These monetary policies include interest rate policy, asset purchase policy, reserve policy, foreign exchange policy, and lending operations. With the issuance of the monetary policies, companies are able to get more funds for production. Since monetary policies has strengthened their confidence in future development, companies will respond to monetary policies with recovering production, which increases the supply of consumptions and hence lowers inflation rate. On the other hand, with the improvement of production expectations, the company's willingness to increase production has increased. However, since the risk of the COVID-19 pandemic is still widespread, recruitment and gathering to production have a high probability of causing the infection of COVID-19 and causing companies to suffer greater losses. Therefore, in order to control costs and risks, companies are more inclined to restore production and increase output by improving equipment, technological innovation, and increasing production efficiency (Chen et al. 2021; Han and Qian 2020; Zheng et al. 2021; Wang et al. 2021), which inversely leads to a rise in unemployment rate. The same as the previous regression result, after excluding the variables containment and stringency, the conclusions obtained remain the same.

3.3. Subsample Analysis

In order to further observe the impact of the COVID-19 pandemic on different economies, we divide the 38 sample countries into two groups, developed and developing countries, and regress them separately. Tables 5 and 6 present the results of grouping regression.

The pandemic has significantly increased inflation and unemployment in developing economies. In contrast, the unemployment problem in developed countries is more obvious than inflation. There is no doubt that the outbreak of the COVID-19 pandemic has had similar recessionary effects on both types of economies.

We similarly also delivered a grouping regression for the impact of the pandemic on the economy after the central bank intervenes in the market. The actions of the central banks have produced different results in developed and developing countries. In developed countries, the results of the regression are completely consistent with our previous conclusions – that is, under the combined effect of the pandemic and central bank activities, inflation has been eased, but the unemployment rate still increases. The situation in developing countries is completely different. Almost all regression results are not statistically significant. This means that the intervention and activity of the central banks did not ease the macroeconomic recession in developing countries as expected. There may be two reasons for the above phenomenon. On the one hand, the monetary policy system framework of developing countries is flawed. Since supply and demand are affected at the same time, the traditional demand management policies during a pandemic may not achieve the desired results (Loayza and Pennings 2020). As a result, the monetary policy transmission time is too long and may partially be ineffective. On the other hand, the commodity market and labor market of developing countries are inadequate, they are subject to more government administrative control, and they are more dependent on the government. This will make the market not actively respond to monetary policies – that is, monetary policies become invalid.

3.4. Robustness Check

In the baseline analysis, we used a panel fixed effects model to test whether the central bank activeness has mitigated the impact of the COVID-19 pandemic on the macroeconomy. To ensure the robustness of our results, we use the dynamic panel model with System GMM (Generalized Method of Moments) estimation to re-estimate the impact of central bank activeness. According to Wooldridge (2015), panel data has three advantages compared with cross-sectional data. First, panel data has advantages in solving the problem of missing variables. Secondly, the panel data better reflects the individual's

Table 5. Result by using sub-samples (developed countries).

Variable	(1) Inflation	(2) Inflation	(3) Unemployment	(4) Unemployment	(5) Inflation	(6) Inflation	(7) Unemployment	(8) Unemployment
Panel A: COVID-19 and Macroeconomy								
Newcase	−0.030		0.222***		−0.055*		0.241***	
	(−0.917)		(2.834)		(−1.940)		(3.557)	
Newdeath		−0.028		0.215***		−0.054*		0.232***
		(−0.856)		(2.768)		(−1.939)		(3.516)
N	210	210	186	186	210	210	186	186
R^2	0.534	0.534	0.323	0.321	0.514	0.514	0.322	0.320
Panel B: COVID-19, Central Bank Activeness and Macroeconomy								
Newcase	0.006		0.140*		−0.027		0.181***	
	(0.189)		(1.825)		(−0.961)		(2.744)	
Newdeath		0.014		0.103		−0.028		0.163**
		(0.417)		(1.339)		(−1.007)		(2.531)
Newcase*CBA	−0.019***		0.044***		−0.019***		0.042***	
	(−3.705)		(3.827)		(−3.627)		(3.719)	
Newdeath*CBA		−0.016***		0.042***		−0.015***		0.039***
		(−3.418)		(4.006)		(−3.131)		(3.791)
CBA	0.185***	0.098**	−0.400***	−0.241***	0.187***	0.093**	−0.380***	−0.218**
	(3.075)	(2.419)	(−2.979)	(−2.687)	(3.075)	(2.278)	(−2.865)	(−2.472)
Control Variables	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Country FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Monthly FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
N	210	210	186	186	210	210	186	186
R^2	0.578	0.572	0.412	0.412	0.554	0.545	0.407	0.404

The control variable and other results are not reported, but are available upon request. Others are the same as in Table 3. t statistics are in parentheses. ***, **, and * indicate statistical significance at the 1%, 5%, and 10% levels, respectively.

Table 6. Result by using sub-samples (developing countries).

Variable	(1) Inflation	(2) Inflation	(3) Unemployment	(4) Unemployment	(5) Inflation	(6) Inflation	(7) Unemployment	(8) Unemployment
Panel A: COVID-19 and Macroeconomy								
Newcase	0.144***		0.105		0.086**		0.161	
	(2.977)		(0.931)		(1.985)		(1.526)	
Newdeath		0.192***		0.249**		0.127***		0.283***
		(4.292)		(2.208)		(3.108)		(2.765)
Panel B: COVID-19, Central Bank Activeness and Macroeconomy								
Newcase	0.157***		0.107		0.111**		0.165	
	(3.114)		(0.896)		(2.394)		(1.453)	
Newdeath		0.204***		0.260**		0.150***		0.307***
		(4.261)		(2.166)		(3.323)		(2.747)
Newcase*CBA	−0.022		−0.002		−0.028*		−0.003	
	(−1.348)		(−0.078)		(−1.736)		(−0.094)	
Newdeath*CBA		−0.011		−0.006		−0.017		−0.012
		(−0.852)		(−0.238)		(−1.262)		(−0.484)
CBA	0.223	0.094	0.054	0.072	0.283*	0.125	0.062	0.116
	(1.466)	(1.134)	(0.176)	(0.437)	(1.856)	(1.486)	(0.200)	(0.700)
Control Variables	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Country FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Monthly FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
N	305	305	173	173	305	305	173	173
R^2	0.377	0.396	0.325	0.345	0.356	0.367	0.287	0.315

The control variable and other results are not reported, but are available upon request. Others are the same as in Table 3. *t* statistics are in parentheses. ***, **, and * indicate statistical significance at the 1%, 5%, and 10% levels, respectively.

dynamic behavior information. Third, compared with the cross-sectional data, the two dimensions of the panel data significantly increase the volume of panel samples, thereby significantly improving the accuracy of the estimation. The dynamic panel model settings are as follows.

$$\begin{aligned} Inflation_{it} = c + \alpha_1 \text{L.Inflation}_{it} + \beta_1 COVID_{it} + \beta_2 Export_{it} + \beta_3 Import_{it} + \beta_4 GDP_{it} \\ + \beta_5 Containment_{it} + \beta_6 Stringency_{it} + \lambda_i + \alpha_t + \varepsilon_{it} \end{aligned} \tag{3}$$

$$\begin{aligned} Inflation_{it} = c + \alpha_1 \text{L.Inflation}_{it} + \alpha_2 CBA_{it} + \alpha_3 COVID_{it} + \alpha_4 COVID_{it} * CBA_{it} + \beta_1 Export_{it} \\ + \beta_2 Import_{it} + \beta_3 GDP_{it} + \beta_4 Containment_{it} + \beta_5 Stringency_{it} + \lambda_i + \alpha_t + \varepsilon_{it} \end{aligned} \tag{4}$$

where L.Inflation_{it} represents the inflation of country i in month $t\text{-}n$ – that is, the lag term of the explained variable *Inflation*; $\text{L.Unemployment}_{it}$ represents the lag term of the explained variable *Unemployment*; $COVID_{it} * CBA_{it}$ denotes the interaction term between newly confirmed cases (deaths) and the central bank activeness of country i in month t. The other variables are the same as those in the panel fixed effects model.

The results of the dynamic panel model are presented in Table 7.[2] To ensure consistency and robustness of the results, we perform three tests in the process of estimating the dynamic panel model. The first two tests are Arellano and Bond first-order (AR1) and second-order (AR2) serial autocorrelation tests, while the Sargan over-identification test is applied to verify the validity of the used instruments. The Arellano-Bond test and Sargan test are also provided in Table 7. The results of AR1 test reject the null hypothesis, indicating that the inclusion of the lagged dependent variable is necessary. The results of AR2 test accepts the null hypothesis, indicating that there is no autocorrelation in the disturbance term. The p-value of the Sargan test of over-identification restriction is larger than 0.1, showing that these used instrument variables are reliable in the estimation.

It can be observed that all results are similar to the baseline results in Tables 3 and 4. The coefficients of the variables *Newcase* and *Newdeath* are 0.059 and 0.019, respectively, and they are statistically significant. This once again emphasizes that COVID-19 has indeed increased inflation and unemployment, and has had a negative impact on the macroeconomy. Under the framework of the dynamic model, the coefficients of the variable *CBA* in columns 1 and 3 are 0.063 and 0.040, and are statistically significant. The coefficients in columns 2 and 4 are −0.531 and 0.040, and are statistically significant. This implies that the more active central bank has a certain regulatory effect on unemployment, but the impact on inflation is not in line with expectations. Similar to the regression results of the panel fixed effects model, the regression results of the dynamic model show that the results of the interaction terms *Newcase*CBA* are statistically significant with coefficients −0.009 on *Inflation* and 0.060 on *Unemployment*. The results of the interaction terms *Newdeath*CBA* are statistically significant with coefficients −0.011 on *Inflation* and 0.073 on *Unemployment*. Accordingly, we hold that that our main findings will not change with the alternative measures of the regression model.

It is worth noting that the lags of the variables *Inflation* and *Unemployment* are statistically significant. This shows that the impact of central bank actions presents a reasonable lag. The statistical significance of the variables' *containment* and *stringency* indicates that the government response may have near-term impacts. Compared to mandatory administrative orders, central bank actions take longer to take effect.

4. Conclusion and Policy Implications

Central bank around the world have showed great activeness and adopted a large number of monetary policies in order to eliminate the economic trauma of the COVID pandemic, but the actual effects of these policies have not yet been paid attention to by researchers. The economic effects of central bank activeness in the post-pandemic era deserve in-depth consideration. Therefore, this paper uses monthly panel data from 38 countries from January 2020 to June 2021 to study the impact of central bank activeness on inflation and unemployment during the COVID-19 pandemic. First, we use the

Table 7. Robustness test – SYS-GMM results.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Variable	Inflation	Inflation	Unemployment	Unemployment	Inflation	Inflation	Unemployment	Unemployment
Panel A: COVID-19 and Macroeconomy								
L.Inflation	0.976***	1.013***			1.052***	1.063***		
	(60.292)	(31.986)			(150.687)	(32.245)		
L.Unemployment			0.933***	0.932***			0.938***	0.922***
			(41.372)	(40.857)			(117.024)	(125.903)
Newcase	0.059***		0.086***		0.067***		0.137***	
	(7.075)		(3.299)		(6.402)		(7.102)	
Newdeath		0.019**		0.155***		0.024**		0.231***
		(2.237)		(3.672)		(2.076)		(9.933)
AR(1) (*P*-value)	0.021	0.017	0.070	0.071	0.012	0.013	0.069	0.068
AR(2) (*P*-value)	0.579	0.346	0.208	0.208	0.615	0.531	0.175	0.172
Sargan (*P*-value)	0.967	1.000	0.996	0.9985	0.952	1.000	0.996	0.997
Panel B: COVID-19, Central Bank Activeness and Macroeconomy								
L.Inflation	0.986***	0.929***			1.061***	1.073***		
	(54.197)	(15.068)			(82.239)	(34.849)		
L.Unemployment			0.991***	0.946***			0.926***	0.912***
			(20.510)	(33.582)			(149.941)	(38.526)
Newcase	0.064***		−0.029		0.056***		0.024	
	(6.293)		(−0.765)		(7.181)		(0.795)	
Newdeath		0.008		0.029		0.013		0.107***
		(0.606)		(0.671)		(1.288)		(3.272)
Newcase*CBA	−0.009***		0.060***		−0.007***		0.063***	
	(−4.649)		(10.336)		(−3.757)		(9.786)	
Newdeath*CBA		−0.011***		0.073***		−0.009***		0.071***
		(−7.000)		(13.501)		(−4.137)		(10.960)
CBA	0.063***	0.040***	−0.531***	−0.417***	0.022	−0.007	−0.577***	−0.385***
	(3.015)	(3.016)	(−7.352)	(−10.780)	(1.382)	(−0.426)	(−7.967)	(−9.975)
AR(1) (*P*-value)	0.018	0.013	0.069	0.070	0.011	0.011	0.065	0.067
AR(2) (*P*-value)	0.492	0.362	0.168	0.156	0.514	0.315	0.142	0.139
Sargan (*P*-value)	0.971	1.000	1.000	1.000	0.953	1.000	0.997	0.998
Control Variables	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Country FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Monthly FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
N	445	445	305	305	445	445	305	305

The control variable and other results are not reported, but are available upon request. Others are the same as in Table 3. *t* statistics are in parentheses. ***, **, and * indicate statistical significance at the 1%, 5%, and 10% levels, respectively.

panel fixed effects model to examine the effect of the COVID-19 on inflation and unemployment, as well as whether the central bank activeness play a role. The empirical results suggest that central bank activeness have a positive effect on reducing the growing pressure from the COVID-19 on inflation, while it cannot mitigate the shock of the COVID-19 on unemployment rate. Specially, government others measure, including containment and health, and stringency policies, have little effect in mitigating the negative impact of the pandemic on inflation and unemployment. The activity and intervention of central banks in developed countries has received considerable market response, alleviating inflationary pressures. However, the markets of developing countries have been slow to respond to the actions of the central bank and have not received the expected results. Our findings suggest that the central bank activeness have heterogeneous effects on different macroeconomic indicators, and cannot mitigate the hurts of the COVID-19 pandemic for all macro indicators during the pandemic. Moreover, we perform the dynamic panel model with System GMM method to ensure the robustness.

The research results of this article give us the following policy enlightenment. Firstly, central banks should maintain a high level of their activeness and use monetary policy tools to reduce the negative impact of the pandemic on inflation. Our results show the positive effect of central bank activeness on reducing inflation, which provides direct evidence for the above implications.

Secondly, government should account for policy cooperation in achieving the policy target. Our empirical results indicate that central bank activeness enhance the negative effect of the COVID-19 on unemployment. This means that only rely on central banks issuing monetary policies cannot systematically eliminate the shock of the pandemic, which calls for policy cooperation. Governments should cooperate with central bank to formulate policy packages.

Finally, our research helps investors, producers and consumers to fully understand the economic and social impact of the central bank activeness and hence set up the corresponding strategy. We believe that our research results can not only provide reliable and valuable information for central banks around the world to formulate reasonable and effective monetary policies and promote economic recovery, but also have some enlightenment for governments around the world.

Notes

1. The sample countries are as follows: Algeria, Argentina, Australia, Brazil, Canada, Sri Lanka, Chile, China, Colombia, Czechia, Denmark, Hungary, India, Indonesia, Israel, Japan, Korea, Kuwait, Malaysia, Mexico, Morocco, New Zealand, Norway, Peru, Philippines, Poland, Romania, Saudi Arabia, Singapore, Vietnam, South Africa, Sweden, Switzerland, Thailand, United Arab Emirates, Turkey, United Kingdom, United States.
2. We also carry out the SYS-GMM regression of the subsamples and conduct another robustness check by using other control variables. All these results are in line with the results of panel fixed effects model. Considering the space limitation, these results are not reported, but are available upon request.

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