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Pandemic uncertainties and fiscal procyclicality: A dynamic non-linear approach☆

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ABSTRACT
In the wake of the ongoing Covid-19 crisis, this study explores evidence of fiscal procyclicality to the previous pandemic cycles between 2000 and 2017 across 143 countries. Using the novel data set of the World Pandemic Uncertainty index (WPUI) and Dynamic Panel Threshold estimation after considering the endogeneity of variables as proposed by Seo and Shin (2016), this is probably the first attempt to model fiscal responsiveness on the censored and discontinuous effect of pandemic uncertainties. Asymmetric responses on public health expenditure are observed. Although evidence of fiscal procyclicality to pandemic uncertainties is found among the high-income countries and also among the debt-ridden countries, the persistence of responses is not observed in the following period. Further, we find higher relative stimulus by the public sector in low-income countries and also among high debt countries than the private sector, in combating pandemic uncertainties. The study is expected to assume significance for the policymakers as it provides historical evidence of how the Governments have reinforced healthcare during earlier pandemics.

1. Introduction

The Covid-19 is the latest among several pandemics that have brought the world to a standstill. It has created widespread uncertainty to the macroeconomic fundamentals of the countries. The various Governments across the globe have been designing fiscal packages to combat its deleterious effect on the economy. History does provide the policymakers cues to understand the fiscal responsiveness of the countries in tackling earlier pandemics. The obvious response by the governments has been in first addressing the concerns of the healthcare sector. One way to gauge the fiscal responsiveness is to see the effect on the patterns of health expenditure, through the independent lens of periodic budgetary allocations and also after cyclical disruptions caused by the onset of pandemics. The present study assesses how the public health spending has been affected across varying structural parameters, when the countries have been beset with pandemic uncertainties.

The variations in health expenditure across nations have been found to be driven primarily by variation of per-capita income as explained by Kleiman (1974) and Newhouse (1977) wherein they recognized that health spending is a luxury good with an elasticity

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measures being greater than one. However, subsequent studies have illustrated the importance of non-income factors like the relative price of healthcare, crude mortality rates, technological innovations, unemployment, immigration, and political factors (see for example Hitiris & Posnett, 1992; Di Matteo, 2005; Braendle & Colombier, 2016, etc.). Apart from the structural issues affecting the health sector, it has been found that cyclical disruptions often bring a curtailment in healthcare spending. Ongaro et al. (2015) discuss how the European nations experienced large targeted cuts in healthcare spending in the wake of the financial crisis in 2008. The one common thread that binds all the above studies is the heterogeneity and dynamic effects across health care expenditure and its determinants in the various countries as also explained by Roberts (1999). However, the real challenge in planning and management of health care expenditure arises at the calamitous outbreak of a pandemic or an epidemic.

Apart from Covid-19 as one of the lethal pandemics, the World Health Organization (WHO) also lists Ebola, SARS, and HIV AIDS to name a few of the other comparable diseases. One of the key concerns while managing this menace is to understand how much of the burden is to be undertaken by the public health authorities and how much to be left to the private participants of the market. Lee and Arno (1986) discuss that there was inadequate federal funding for research, treatment, and community-based services during the time of the AIDS epidemic in the United States. Ideological obstinacy and bureaucratic hassles had led to reduced coordination in policy-making and funds were re-allocated from already existing healthcare programs to serve the purpose of AIDS. Fiscal re-allocations are primarily a result of various fiscal rules and constraints on the extent of government deficit that the countries can afford to maintain and the resulting debt burden arising out of it. Johansson (2007) uses an open economy dynamic model to show that the optimal government policy for South Africa at the peak of the AIDS epidemic was to reduce the tax rate and allow government debt to increase. The basic argument behind this conclusion is that large health care expenditure along with certain epidemiological interventions had to be undertaken owing to the rising dependency ratio. The younger working population were found to be the most vulnerable group to AIDS which is consistent with the results of Kabajulizi and Ncube (2017). This leads to a rise in present period debt but transfers the debt servicing to future generations. While the above depict country-specific fiscal impact of AIDS, Dieleman et al. (2018) have discussed how health spending has surpassed actually $10 trillion for 188 countries between 1995 and 2015 resulting in the prevention and treatment of AIDS to a large extent. The large spending has predominantly been undertaken by the Government and through development assistance from various organizations to finance the HIV AIDS related programmes while a very nominal 10 per cent was attributed to out-of-pocket expenses as in 2015.

The fiscal implications of the prevalent Covid-19 pandemic are also being studied at a nascent stage as the holistic framework can be realized only once the pandemic loses its sting in most countries and normalcy is restored. Among the limited number of unpublished studies, Faria-e-Castro (2020) has tried to study the effect of several one-time fiscal shocks of around 3.7 percent of Gross Domestic Product (GDP) on the economy using a non-linear Dynamic Stochastic General Equilibrium (DSGE) Model. Kemp-Benedict (2020) links the epidemiological-macroeconomic scenarios to conclude that the combined effect of testing from the health sector and fiscal stimulus can balance the lives-likelihood debate and help offset the recession. Based on the limited work related to pandemics, our study is probably the first of its type to make an attempt in providing evidence to the fiscal responsiveness of the countries to previous pandemics. We primarily limit fiscal responsiveness to the health sector as it is of immediate concern after a pandemic outbreak. The World Pandemic Uncertainty Index designed by Ahir et al. (2018) has been used as the proxy for signals of pandemics. To capture the heterogeneity in responses by the ‘information-lead’ and ‘information-laggard’ countries in stimulating health expenditure in response to pandemic uncertainties, non-linearity vis-à-vis income-level has been considered. Furthermore, the heterogeneity in fiscal responses vis-à-vis fiscal space (that is the government’s flexibility in spending choices) of economies has also been checked. The rest of the paper is organised as follows. This introduction is followed by a detailed discussion on theoretical and empirical methodologies, and data used in section 2. Section 3 discusses the empirical results obtained, and Section 4 presents the results of an out of sample forecast analysis. Lastly, Section 5 summarizes the findings.

2. Methodology

2.1. Theoretical understanding

The present study has followed the theoretical model presented by Cardon and Hendel (2001), to understand how the governments acting as social welfare maximizers react to signals on pandemic uncertainty and are subject to asymmetric information. At the onset, it is assumed that a two-period decision strategy has been adopted by the government where the first period represents the immediate response and the second is the lagged response. In the first period, the government chooses the partial pre-pandemic healthcare expenditure that yields the highest level of social welfare, based on some internal discussions within the country. In the second period, after the news on pandemic is realized and reports are confirmed, the government again reacts. The pandemic uncertainty has been modelled by assuming a social welfare function as follows:

\[ U = U(m; h) \]  

where \( m \) represents the fiscal expenditure on all other goods except healthcare and \( h \) represents the healthcare expenditure by the government. The latter is expressed as \( h = x + s \), where \( x \) represents the healthcare expenditure in non-pandemic times while \( s \) represents the random disturbance shock created by the pandemic, leading to a rise in \( h \).

Now, it is assumed that the government gets a signal \( w \) of the future health state \( s \) before going for the partial release of funds. The government makes an assessment of the future health status of the country based on these signals. The conditional distribution (on the pandemic uncertainty signal) is used to compute expected social welfare that the government aims to maximize in the first period. We
employ backward solution method, where anticipations of future uncertainties influence current behaviour. We begin from the second stage, when the signals on the pandemic are more widespread. The objective of the government is to maximize social welfare \( U(m, h) \) subject to the fiscal balance \( m + h = y \) and choose the optimal health expenditure where \( y \) is the revenue of the government. The fiscal balance of the government further determines the debt burden of the government to finance the shortage.

Now, going back to the first stage, the government observes the signal and decides on its pre-pandemic health expenditure and other public expenditure. Based on the indirect social welfare function \( V(w, a) \) which depends on the signal and some policy specific random changes called \( a \) (such as constrained fiscal space), the second stage behavior is ascertained.

\[
V(w, a) \equiv E(U(s)w) + a = \int U(y, Z)\pi(dz / w) + a
\]

where \( V(w, a) \) is the expected social welfare given the signal \( w \) and other policy associated changes called \( a \) and \( \pi(dz / w) \), and distribution of final health state \( s \) conditional on signals \( w \).

At the first stage, the government chooses the partial release of funds based on maximizing expected utility given the private signals \( \text{max}(V(w, a)) \). By integrating over the realizations of the signal, the model in its implicit form predicts how much the government spends during and after the passage of the first period, given the signals from the pandemic discussions. Thus, from \( \text{max}(V(w, a)) \) we obtain

\[
h^* = h(w, a)
\]

where \( h^* \) represents the optimal public health expenditure.

### 2.2. Empirical methodology and data

Based on the above-described theoretical model, we have estimated the relationship between public health expenditure and pandemic related signals. To check the possible presence of asymmetric information, that is whether the ‘information-lead’ countries react differently from ‘information-laggard’ countries, a non-linear dynamic econometric technique has been applied. There have been several studies in the past, such as by O’donnell et al. (2007), Wu et al. (2014), and Bilger and Manning (2015) which show that health sector variables are neither continuous nor fully observed. This censored nature of the variables has led to increased attention on the usage of non-linear estimation of health sector variables.

In the present study we have employed the dynamic panel threshold estimation technique. In literature, panel data estimation with threshold variables using Hansen (1999) method has been commonly used. However, the Hansen (1999) method is found to be incompatible with many macroeconomic applications, like that of the present study, as the method is appropriate for the static panel model, and the fixed effect estimator in it requires the covariates to be strongly exogenous. Hence, in the present study an extended model of Hansen (1999) proposed by Seo and Shin (2016) encompassing the dynamic relationship along with endogenous covariates, popularly known as the dynamic panel threshold model, has been used. The first-differenced generalized method of moments (FD-GMM) estimation technique has been used to deal with the potential endogeneity issues, using Arellano and Bond (1991) type instruments.

In this study, the threshold methodology is used to explore whether the effect of pandemic signals on health expenditure varies with the level of per-capita income and the state of public finances, captured by the fiscal debt. Owing to the lack of instantaneous response to pandemic signals, there is a need to analyse the problem in a dynamic framework. The equations estimated are as follows:

\[
GHE_{it} = \alpha_i + \beta_1 GHE_{it-1} + \beta_2 \ln GDPPC_{it} + \beta_3 PUI_{it} + \eta_i \ln GDPPC_{it-1} + \gamma_1 \ln GDPPC_{it-1} + \gamma_2 \ln PUI_{it-1} + \delta_1 I(\text{FDY}_it > \gamma) + \eta_i
\]

and

\[
GHE_{it} = \alpha_i + \beta_1 GHE_{it-1} + \beta_2 \ln GDPPC_{it} + \beta_3 PUI_{it} + \eta_i \ln GDPPC_{it-1} + \gamma_1 \ln GDPPC_{it-1} + \gamma_2 \ln PUI_{it-1} + \delta_1 I(\text{FDY}_it > \gamma) + \eta_i
\]

where \( \gamma \) is the threshold parameter. The \( \alpha_i \) and \( \eta_i \) are the intercept and the stochastic error terms, respectively. The \( \delta_1 \) is the difference of the constant terms between the two regimes. The coefficient of one variable is \( \beta_k \) when the threshold variable is more than \( \gamma \) and equals \( \beta_k(k = 1, 2, 3, 4) \) otherwise.

In order to remove the individual effects, the first difference transformation has been considered as follows:

\[
\Delta GHE_{it} = \Delta x_{it} \hat{\beta} + \Delta' \hat{X}_{it} \hat{\delta}_i(\gamma) + \Delta \hat{\eta}_i \quad i = 1, 2, \ldots, n; \ t = 1, 2, \ldots, T;
\]

where \( x_{it} \) is a vector of four explanatory variables, \( \Delta \) is the difference operator, \( \hat{\beta} = (\hat{\beta}_1, \hat{\beta}_2, \hat{\beta}_3, \hat{\beta}_4) \) and \( \gamma = (\gamma_1, \gamma_2, \gamma_3, \gamma_4) \). The unknown parameters \( \theta = (\hat{\beta}', \hat{\delta}', \gamma) \) has been estimated by grid search method minimizing the objective function in the GMM estimation technique as suggested in Seo and Shin (2016). Lastly, following, Seo et al. (2019), we have also employed a bootstrap test of linearity with null hypothesis, \( H_0 : \beta_k = 0 \) against the alternative hypothesis \( H_1 : \beta_k \neq 0 \) for any \( \gamma \in \Gamma \), to check the possible presence of threshold effect. Thus to summarize, first, for a selected threshold value \( \gamma \), the various parameter estimates are obtained following which the
step is repeated for gamma belonging to a subset of the threshold variable. This threshold value is repeated within the subset of threshold independent variables. The threshold value which minimizes the GMM function are the optimal estimated parameters.1

Now, as the study intends to examine the fiscal procyclicality and countercyclicality of pandemic uncertainties, we have used the ratio of public health expenditure to GDP as the explained variable; and real per-capita GDP and pandemic uncertainty index (PUI) as the endogenous and exogenous explanatory variables, respectively. The positive response of fiscal expenditure to pandemic uncertainty has been defined as fiscal procyclicality and negative response as fiscal countercyclicality. The pandemics have been treated to be a healthcare cycle where the heightened fear about pandemics represents a boom and reduced fear represents a bust. Then the relative responsiveness of the public health expenditure and private health expenditure has been checked. Both these effects have been captured using per-capita Gross National Income and ratio of Public Debt to GDP as threshold variables. These results are observed both on a contemporaneous and lagged basis to capture the dynamic effects of health sector expenditure.

For the purpose of empirical analysis, data for 143 countries during 2000–2017 have been used. The data on public and private health expenditure as a ratio to GDP and the data for the real per-capita GDP have been obtained from the database of World Development Indicators. The PUI as designed by Ahir et al. (2018) has been used as the proxy for either an existing or an imminent pandemic in the country. This index is based on internal discussions on pandemics not just within the country but also on the aggregate global level. The index is constructed using text mining techniques and arriving at the frequency of the times a word related to pandemics, is mentioned in the Economist Intelligence Unit (EIU) country reports. The index is then calculated by computing the percentage of the words related to pandemic episodes in EIU country reports, multiplied by 1000. A higher number means a higher discussion about pandemics and vice versa. The keywords that were searched in the Economist Intelligence Unit country reports include Severe Acute Respiratory Syndrome, SARS, Avian flu, H5N1, Swine flu, H1N1, Middle East respiratory syndrome, MERS, Bird flu, Ebola, Coronavirus, Covid-19, Influenza, H1V1, World Health Organisation, and WHO. The World Pandemic Uncertainty Index (WPUI) is a broader measure of pandemic uncertainty capturing discussions not just within the country but across the world. The summary of the discussions across the pandemics is shown in Fig. 1. SARS and Ebola seem to be the most discussed two pandemics during the given period.

3. Empirical results and discussion

Empirical results presented in Table 1, try and validate the theoretical framework by evaluating the fiscal response to the signals received on pandemics. The coefficient $\delta$ refers to the coefficient on an explanatory variable when the threshold variable is greater than $y$ (that is $q_0 > y$). From the table, it is observed that high-income countries tend to have a fiscal procyclical effect to pandemic uncertainties at level while low-income countries have the same effect at lag. It can be argued that this is caused by information asymmetries across countries especially in gauging the magnitude and nature of the shocks caused by the pandemic cycle. This is very similar to how countries respond during different phases of the business cycle as pointed out by Bertola and Drazen (1993) who claim this to be one of the most important sources of non-linearities to fiscal policy effects. These asymmetries could be anticipated or unanticipated depending on the efficiency of the Government in power in the countries.

As far as information asymmetries in lower-income countries are concerned, the problem is even more acute as explained by Leonard et al. (2013) because they suffer from lower standards of regulation and governance. These results are supported by Getzen (2014) and Heijink et al. (2013) who argue that the lagged effects could be accentuated by the time taken to hire and train new personnel, disbursement of funds and for fiscal adjustment to shocks. Another reason attributed to the delayed fiscal response as explained by Afonso et al. (2010) is the consequence of exogenous political and electoral processes. But the difference in signs at the contemporaneous and lag period suggest the absence of persistence in healthcare spending even after healthcare shocks.

The other source of non-linearity in public healthcare spending arises on account of the presence of large amount of public debt in the countries. The high debt countries experience fiscal procyclicality at level but quickly re-adjust to reduced expenditure at lag. Durairaj and Evans (2010) have stated that fiscal space for health is very limited in most countries and public debt acts as one of its major constraints. Fiscal space is defined as the capacity of the government to provide additional budgetary resources for the desired purpose without any prejudice to the sustainability of its financial position. One of the reasons why high debt countries react more contemporaneously to pandemic uncertainties is because there is often re-prioritization of expenditure carried out in the essential sectors as also pointed out by Heller (2006); Behera and Dash (2019) and Tandon and Cashin (2010). Thus, governments are forced into the generation of fiscal space for health in times of pandemic uncertainties, but owing to strict fiscal rules, they quickly re-adjust and cut back expenditure in the next period. On the other hand, the low debt countries increase health expenditure only after the pandemic signals intensify in the next period. They would be depending on the private sector to bail them out initially to adhere to fiscal rules and hence delay their release of funds.

Thus, the balancing of public and private provisioning in the context of pandemics becomes a crucial issue to tackle. Their difference in emphasis with respect to improving health capabilities and increasing affluence could lead to different development policies being adopted by the economies as pointed out by Anand and Ravallion (1993). Furthermore, we try and assess the relative expenditure responsiveness of the government and private sector in pandemic uncertainties. For low-income countries, the relative reliance is more on the public sector compared to the private sector, whereas the more market friendly high-income countries tend to have relatively more robust private sector funding. The finding is in line with the arguments of Bhalotra (2007). We also observe that as the spread of pandemic signals gets stronger in the next period, the relative dependence on the private sector tends to increase as the public sector’s coffers run dry. As far as high debt countries are concerned, the relative dependence on the public sector is more as the private sector

1 For a detailed discussion on the methodology please see Yu et al. (2020).
would be slow in investing especially if it anticipates a rise in taxes by the government to bridge the fiscal deficit. Further, an increase in government spending puts upward pressure on interest rates which, in turn, leads to lower private investment, popularly known as crowding-out effect as has been explained by Kormendi (1983) and Demirci et al. (2019). However, the dominance of the private sector in financing healthcare expenditure is consistent across low debt countries.

4. Out of sample forecast for the Covid-19 pandemic

Now, we have attempted to forecast the change in public health expenditure as percentage of GDP in 2020 using our estimated model...
and available data on pandemic uncertainty index (see Table 2). We have grouped the top twenty countries based on the number of Covid-19 cases across countries. The expected rise in public healthcare expenditure reflects the responsiveness of the respective governments on the basis of the pandemic uncertainty signals and massive inadequacy in public investment in the healthcare sector, before the onset of the Covid-19 pandemic. As far as heterogeneity in policy responses across countries is concerned, it is quite clear that European countries like the United Kingdom, Italy and Germany have been far more proactive in reacting to pandemic signals by a higher proportion of expected rise in healthcare expenditure. Interestingly, the top three countries severely affected by Covid-19 namely USA, India and Brazil are lying at the 14th, 16th and 12th position respectively when ordered by the expected rise in public healthcare expenditure. This clearly suggests that policy reactions in the countries have not been commensurate with the rising pandemic cases. As far as the proportion of deaths recorded among the top three countries is concerned, it below the average death rate in the top twenty countries, but there are countries like Chile, Germany and Spain, who have reacted far more actively in spite of lower death rates. As argued previously, the more intensified policy response could be related to macroeconomic conditions like the debt conditions of the countries rather than the deaths from the pandemic. While Chile, Germany and Spain were found to be higher debt countries with respect to the obtained threshold debt, the tepid response of the more severely affected countries could be a result of delay in the pandemic signals to intensify, before devising policies on disbursal of funds.

We have further plotted pandemic uncertainty indices during the Covid 19 and the deaths per thousand population for the respective countries (see Fig. 2). We find consistency in our previous results where we observe that reactions to the pandemic signals are being governed to a large extent by the existing macroeconomic conditions. The deaths to population ratio of 67 per cent is almost similar to countries like the United Kingdom and the United States of America but the United Kingdom has responded close to three times more than the USA in their policy discussions for the pandemic. Here again, higher debt burden has pushed UK for a more contemporaneous policy response. Thus, the intensity of the pandemic signals plays a key role in determining the public healthcare expenditure during the pandemic. A low pandemic uncertainty signal does not necessarily refer to lower pandemic outbreak but the relative inaction by the governments at the onset of the pandemics. This is probably why countries which reacted early enough have been relatively better off in keeping a check on the number of the rising pandemic cases.

5. Conclusion

The unique contribution of the study is to model the non-linear relationship between pandemic uncertainties and public health expenditure using the Dynamic Panel Threshold approach. This approach allowed us to capture the threshold level of per-capita income and government debt, which would effectively determine the fiscal response to several pandemic signals. By exploring the preparedness

| Table 2 |
|------------------|------------------|
| Expected Rise in Public Health Expenditure on account of rise in Pandemic Uncertainty in 2020. |
| Countries | Pandemic Uncertainty Index | Expected rise in healthcare |
| United States of America | 19.73 | 0.90 |
| India | 13.35 | 0.46 |
| Brazil | 31.08 | 1.13 |
| Russia | 9.05 | 0.76 |
| Argentina | 12.92 | 0.08 |
| Spain | 21.75 | 2.06 |
| Colombia | 29.09 | 2.68 |
| France | 18.30 | 1.74 |
| Peru | 29.29 | 2.73 |
| Mexico | 30.56 | 2.84 |
| United Kingdom | 66.54 | 6.54 |
| South Africa | 30.75 | 1.19 |
| Islamic Republic of Iran | 17.91 | 1.58 |
| Chile | 31.46 | 2.94 |
| Italy | 33.06 | 3.21 |
| Germany | 27.07 | 2.66 |
| Bangladesh | 0.001 | 0.01 |
| Indonesia | 4.32 | 0.37 |
| Philippines | 1.70 | 0.11 |
| Turkey | 12.16 | 0.97 |

Note: Change in public healthcare expenditure as percentage of GDP has been estimated using pandemic uncertainty index (average of quarterly estimates available till date) and real per-capita GDP.

Sources: i) Pandemic Uncertainty Index are taken from Ahir et al. (2018); ii) Forecasted estimates of Per-capita Real GDP are obtained from World Economic Outlook, 2018.

2 We thank the reviewer for suggesting us to incorporate this analysis.
3 Data as on October 23, 2020.
of the governments in earlier pandemics, this study explains how the countries have traditionally carried out re-prioritization of expenditure to address the immediate concern of the healthcare sector. The variation in procyclical effect across income and debt categories of countries gets pronounced as pandemic uncertainties tend to impact the lower-income countries late compared to higher income countries, which is a result of asymmetric information across countries. These results are also consistent with pandemic signals felt across the globe during the prevalent pandemic of Covid-19. Any fiscal response would need to take into account not just the cases and casualties of the pandemic but also the current state of the economy, based on its historical performance. As the countries are battling the Covid-19 pandemic, this study stresses the importance of information asymmetries across countries in designing the stimulus for the healthcare sector. The low-income countries are most vulnerable to the pandemic cycles owing to lack of proper health infrastructure. Hence, it is important that the public and the private sector join hands in bailing out the healthcare sector, especially when the pandemic signals are at their nascent stage.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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