Comments and Discussion

COMMENT BY

ŞEBNEM KALEMLI-ÖZCAN The paper by Goldberg and Reed is an early account of the experience of emerging market and developing economies (EMDEs) with the COVID-19 crisis. The paper focuses both on health and economic fronts. The key message of the paper is that, as of July 15, 2020, EMDEs have fared relatively well. The authors argue that on the health front, the low number of deaths in EMDEs can be explained by the fact that EMDEs have younger populations and lower obesity rates. On the economic front, Goldberg and Reed draw upon the experience of EMDEs with world prices during the previous crises and compare this experience with the current prices given the lack of real-time data on economic quantities. They argue that COVID-19 is playing out as a typical commodity bust for the EMDEs and conclude that the short-run economic effects will be limited. They further argue that the medium- and long-run effects can be devastating due to the indirect effects of the containment and lockdown policies on education and health. The authors caution that their conclusions can be reversed if infections and deaths accelerate in EMDEs.

I am an optimist and hope to see the effects of this pandemic on EMDEs to be limited. However, I would be more cautious than the authors and argue that it is too early to decide on the health and economic costs of the pandemic in EMDEs based on what we know so far. My main argument rests on two premises. First, treating EMDEs as a group to decide on short-run health and economic costs might be misleading. This grouping would mean that we rely on cross-country variation that mixes developing economies (DEs), such as Ghana and Ethiopia—which are among the world's poorest countries—with emerging markets (EMs), such as Brazil, Mexico, and Turkey. Large emerging markets such as Turkey and Mexico are Organization for Economic Cooperation and Development (OECD) countries and part of the Group of Twenty (G-20). If we treat them as a group, we will be underestimating the external dimension of this crisis on these countries from three angles: (1) COVID-19 is not only a commodity price shock for EMs, where most EMs are commodity importers and not exporters. These EMs suffer from capital outflows and depreciating currencies with a detrimental effect on their large foreign currency debts (Cakmakli and others 2020). Since COVID-19 involves a large risk-off shock in financial markets, it is not surprising that the immediate effect on EMs will be capital outflows and depreciations. With the low external demand from advanced countries and disruptions in the global supply chains, the impact of the pandemic on such EMs' economies will not mainly come from the bust in the commodity prices. (2) Many DEs in Africa are far less traveled to than large EMs such as Brazil and Mexico, which experienced many cases and an increasing number of deaths since June 2020. (3) In terms of external debt patterns, EMs and DEs differ drastically, where DEs' debt is owed to official creditors and hence has a better chance to be reduced via schemes like organized debt moratoriums, whereas a large part of the EMs' debt is owed to private creditors. In addition, the main borrowing sector in EMs is not the sovereign, as in DEs, but the private sector (Avdjiev and others 2017). Policies aimed at reducing the burden of sovereign-to-sovereign debt versus private-to-private debt have to be different.

Second, cross-country regressions compare countries' average outcomes. To understand the health and economic effects of a fast moving and highly uncertain crisis such as COVID-19, we need to use time-variation from within these countries. As these data will be limited, we need to combine such inference with estimates from economic-epidemiological models for EMDEs and also draw upon historical experiences as much as we can.

The policy implications will differ given the different narratives about the effects of the pandemic in EMDEs. If the external dimension of the crisis were to be misread, and consequently the health and economic impact were thought to be limited in the short run, then the policy recommendation will be to argue against containment and lockdown policies, since those policies will have adverse effects on education and health in the long run as argued by the authors. However, if the short-run health and economic impact were to be larger, then strict lockdown policies early in the pandemic might be the only way to avoid such large losses, by taking the disease under control quickly, at the same time giving policymakers time to invest in testing and tracing strategies to be used effectively once the economies reopen.

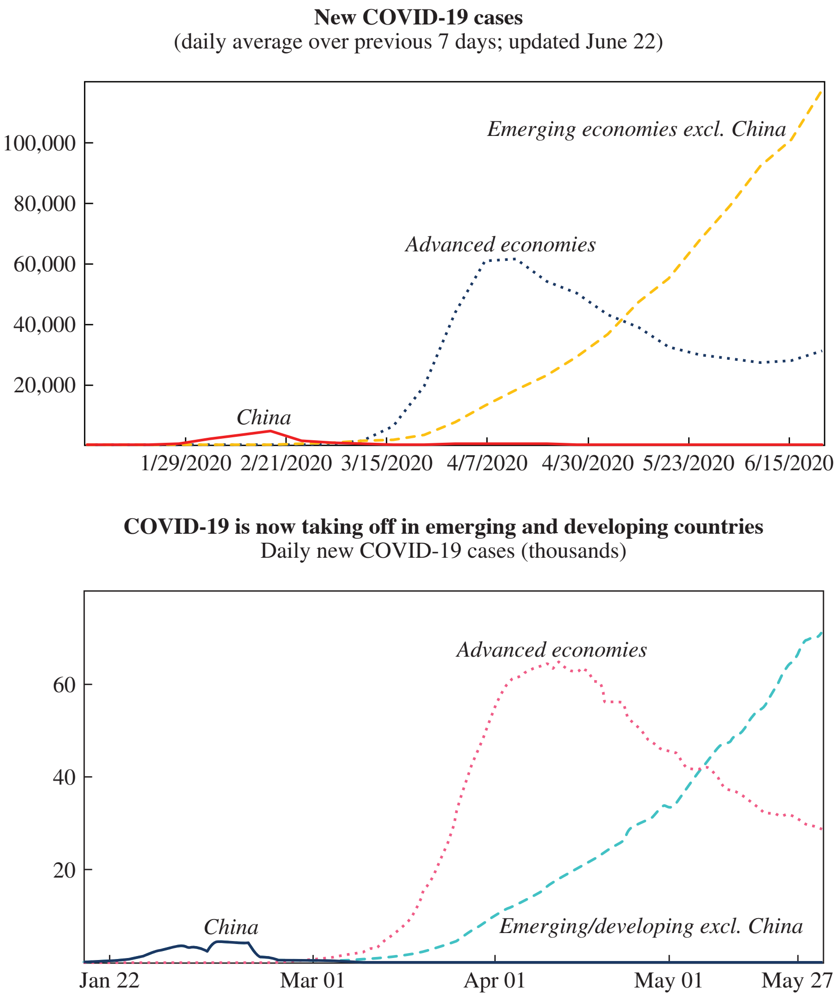
To detail my arguments, I am going to start with figure 1, which shows the number of new daily cases for EMDEs and advanced economies (AEs) based on data from Johns Hopkins University. The figure separates China out of the EMDEs as the disease is under control there. The figure clearly shows the fast increase in infections in EMDEs relative to AEs, with a late start. This means that if we only focus on a number of deaths metric as done in the paper, we will miss the evolution of the epidemic. It might be that the populations of EMDEs are healthier than AEs' populations, and so deaths may increase at a slower rate going forward. We do not know. However, the speed of the increase in new cases is noteworthy, suggesting it might be only a matter of time before we see more deaths in EMDEs. We can see the speed by comparing top and bottom panels that both plot the same data from different dates; the top panel plots the cases as of June 22, and the bottom panel plots the same data as appeared in the column by Martin Wolf in the *Financial Times* on June 9, 2020.

In order to understand the mechanics of the key finding in the paper, namely, that rich countries have more deaths, I have performed a few additional analyses using Goldberg and Reed's data. I plot below in figure 2 results from the same regression that the authors run using their data from countries on the top panel and using micro data from US counties on the bottom panel. It is clear that while rich countries have more deaths as shown in the paper and here in the top panel, rich counties have fewer deaths as shown with the positive relation between the poverty rate and the number of COVID-19 deaths at the county level in the bottom panel.

This shows that GDP variables in the cross-country regressions capture something else, not income, and that something else is positively correlated with income. Goldberg and Reed argue that the missing variables that are positively correlated with GDP are demographics and health. They show that upon controlling for fractions of the older population and obesity rate in a country, the GDP variable becomes insignificant and cannot explain the COVID-19 deaths anymore. Instead, now countries with older populations and countries with higher obesity rates are the ones with higher COVID-19 deaths. Since EMDEs have lower obesity rates and younger populations, their death rates are low according to these results.

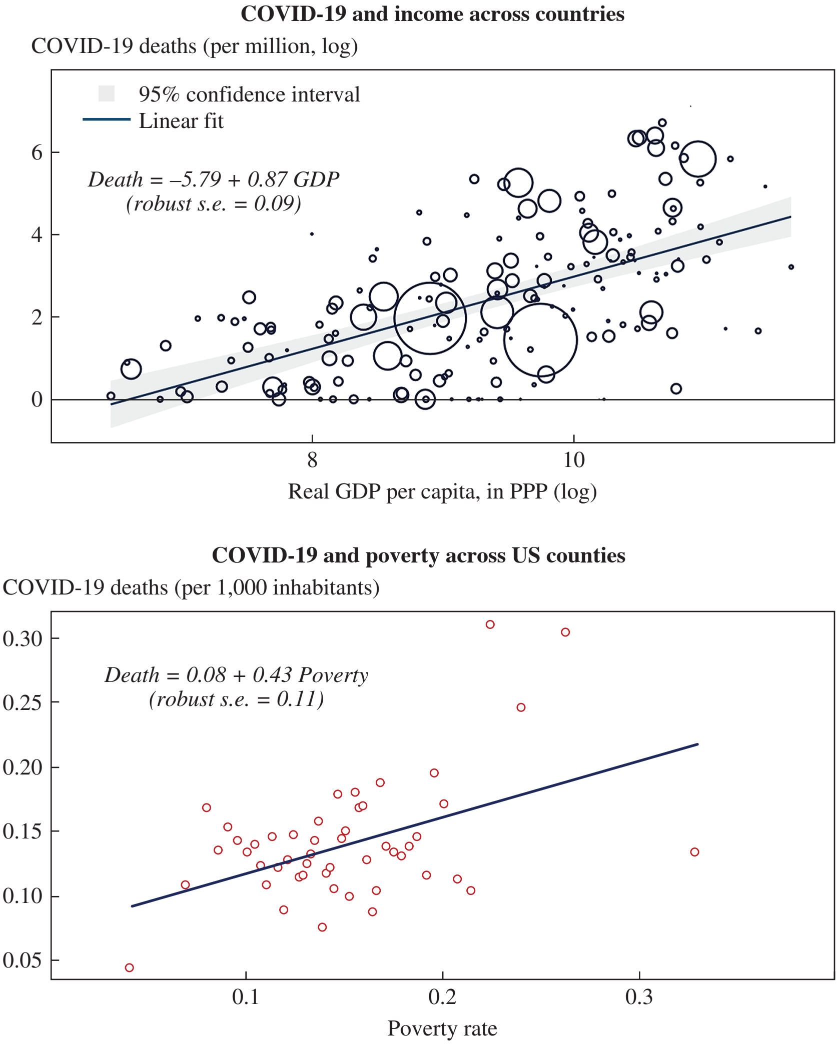
Of course, there are other potential suspects that are positively correlated with GDP and can explain the lower deaths in EMDEs. For example, the late arrival of the pandemic to EMDEs should be able to explain the lower

Figure 1. COVID-19 New Daily Cases from EMDEs and AEs



Source: Johns Hopkins University (top); Wolf (2020) (bottom).

Figure 2. COVID-19 Deaths and Income



Source: Chen and others (2020).
Notes: Top panel shows unweighted regression. Bottom panel shows binned plot with state fixed effects.

Table 1. Additional Dependent Variables Affecting COVID-19 Deaths per Million

	(1)	*(2)*	*(3)*
Ln (GDP per capita)	0.56**	0.35**	0.29
	(0.23)	(0.17)	(0.19)
Days since first death	0.46***	0.45***	0.38*
	(0.10)	(0.08)	(0.23)
Ln (COVID-19 tests/1,000)	0.35*	0.67***	0.73***
	(0.20)	(0.14)	(0.15)
Test ratio		0.05***	0.05***
		(0.01)	(0.01)
Contact Tracing Index			–0.48**
			(0.20)
R^2	0.50	0.62	0.67

Source: Author's calculations.
*$p < .10$; **$p < .05$; ***$p < .01$.

deaths. Or, it could be that there is widespread misreporting in EMDEs relative to AEs in terms of deaths. The authors control for these and still find a strong effect of demographics and health. It can also be the case that in EMDEs there is better contact tracing as individual liberties might be more limited in those countries. In fact, in my analysis that uses the authors' data, I found out that testing and contact tracing can explain the GDP effect on COVID-19 deaths in EMDEs. This result is striking as these variables have a strong negative effect on COVID-19 deaths, independent of the effects of demographics and health. As shown in table 1, conditional on testing and the late arrival of the pandemic, contact tracing is negatively correlated with GDP, as EMDEs did a better job than AEs in this regard. This can explain lower deaths in EMDEs, and it renders the positive effect of GDP insignificant. These results are reassuring in terms of the positive effects of the right public health policies; since the pandemic arrived later to EMDEs, they had more time to prepare, obtained more knowledge, and observed the policy mistakes in other countries. By introducing the right public health policies early on, they might have reduced the number of deaths.

The lower number of deaths in EMDEs so far does not mean that the short-run economic impact is limited. In fact, I would argue that in spite of the limited number of deaths, the short-run economic impact has been devastating for EMDEs as far as we can observe. The lack of real-time data on GDP and capital flows makes the exact measurement of the short-run economic impact hard, but we can put together bits and pieces of information for a coherent picture that shows large economic costs in EMDEs so far.[1]

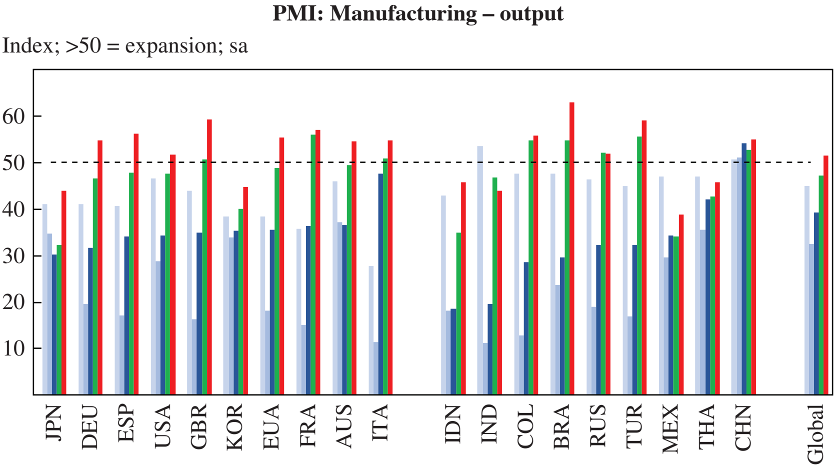
The first step to understand the economic costs for EMDEs is to realize that this shock is a multitude of shocks for these countries and not only a commodity price bust, as argued by Goldberg and Reed. It is a health shock, external supply shock, external demand shock, and capital flow shock. All these shocks combined will lead to depreciating exchange rates and output losses. In the absence of real-time data on GDP and capital flows, I will use data from surveys that track industrial production to proxy for GDP and rely on historical dynamics of capital flows during EMDEs' crises combined with models to estimate the short-run economic impact.

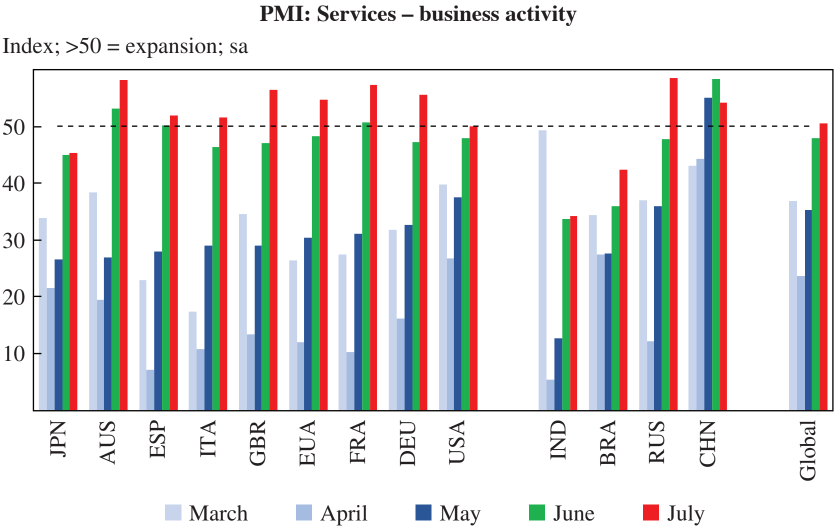
Figure 3 plots data from a Purchasing Managers' Index (PMI) survey that tracks production both in manufacturing and services sectors and almost in real time (released with a one-to-two-month delay). Both panels show that there is very little difference between EMDEs and AEs in terms of short-run economic output losses in these sectors. Using similar data and making projections, the International Monetary Fund (IMF) has a similar argument in the World Economic Outlook (WEO) for June. Compared to the WEO for April, the IMF (2020) is projecting a deeper recession in 2020 and slower recovery in 2021 in the June WEO. They argue that no country will be spared where global growth will decline –4.9 percent in 2020. In fact, growth in EMDEs will decline −5 percent (excluding China) and a cumulative hit to GDP growth over 2020–2021 in EMDEs is expected to exceed that in AEs given the limited policy space of EMDEs (IMF 2020). For the few countries for which we know the second quarter GDP, the numbers confirm the devastating short-run economic impact. Mexico's economy contracted 17.3 percent in the second quarter compared with the previous three months (Webber 2020).

What about capital flows? Given the absence of balance of payments data we cannot know what is going on with total capital flows until later in the year. Many, including Goldberg and Reed, use alternative high frequency real-time data on portfolio flows from the Institute of International Finance (IIF) that show record portfolio equity outflows since February 2020 (around $100 billion). Although unprecedented, portfolio equity is not an important asset class for EMDEs, constituting less than

1. Second quarter GDP and balance of payments data for capital flows will only be available later in the year. Since the pandemic started at the end of first quarter in EMDEs, the first quarter GDP will not be informative.

Figure 3. Production in Manufacturing and Services: EMDEs and AEs





Source: PMI data from IHS Markit.

20 percent of total capital flows (Avdjiev and others 2017). IIF data also show that there are portfolio debt outflows of around $30 billion from EMDEs since February 2020. This amount is not unprecedented as it is much less than what came out of EMDEs during the global financial crises of 2008.[2]

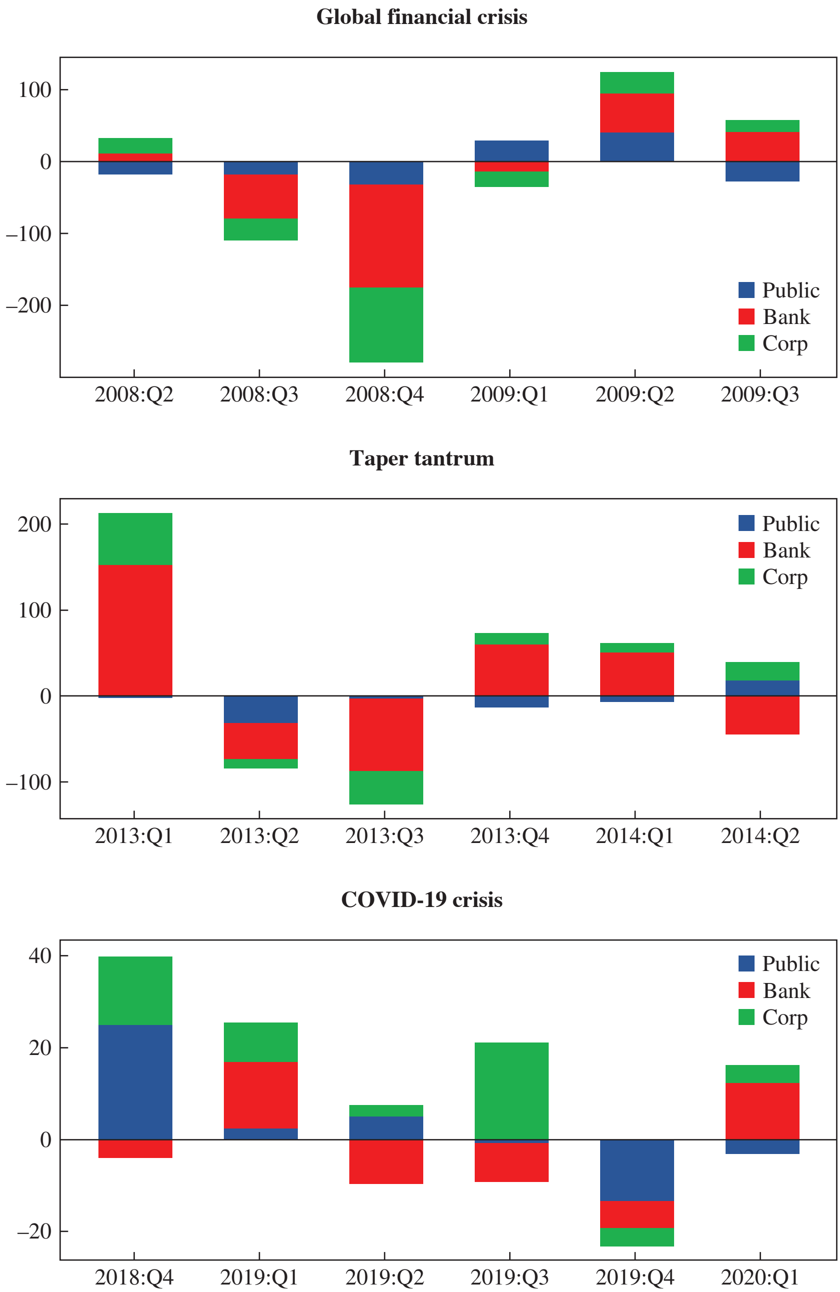
Both of these types of portfolio flows are now stabilized, and it seems like there are not large outflows from other asset classes. In EM (DE) countries more than 60 percent (70 percent) of capital flows are in debt, and the rest is in equity, mostly in foreign direct investment (FDI) (Avdjiev and others 2017). The share of loans in this debt is more than 60 percent for EMs and more than 80 percent for DEs. These figures suggest that cross-border bank loans and corporate loans play an overwhelming role in total capital flows to EMDEs. We know from previous EMDEs crises which were much smaller risk-off shocks than COVID-19 that these asset classes are sensitive to risk-off shocks, and real troubles start when banks and corporates start losing the foreign capital in large amounts.

To make this case, figure 4 plots capital flows by nonresidents to corporate, bank, and sovereign sectors during the global financial crisis and taper tantrum on the top and middle panels, and during COVID-19 on the bottom panel, using thirty-four EMDEs.[3] During the global financial crisis and taper tantrum events, foreign investors in EMDEs pulled out of domestic banking sectors the most, as well as the corporate sectors to a certain extent. However, adjustments to debt flows were limited during the COVID-19 shock. If anything, they were mostly out of the sovereign sector, as flows to the banking sector held stable. Since these data are mainly for the first quarter of 2020, it also includes large inflows into EMDEs (especially to corporates) in January and February before the crisis fully took hold. Updated data for the second quarter of 2020 may reveal larger declines in inflows, including to banks, as experienced during previous crises. The reason why foreign investors left sovereign

2. IIF data only cover portfolio equity and portfolio debt flows. IIF data are also available only for a limited set of countries. IIF collects real-time data either through central banks who report real-time portfolio flows or use fund-level data from Bloomberg. For example, for bond flows, IIF only includes India, Indonesia, Thailand, South Africa, Hungary, Turkey, Mexico, Poland, and Ukraine. For countries whose data are not available, IIF does a valuation adjustment to stocks to nowcast the portfolio flows. The larger set of countries in which they track NET capital flows does not provide real data but an estimate based on the current account and reserves. As we know from previous EM crises, what matters is gross flows and not the current account, especially gross banking flows and corporate flows, both of which IIF data will not cover.

3. The figure is adapted from Avdjiev and others (2017).

Figure 4. Gross Capital Flows during EMDE Crises

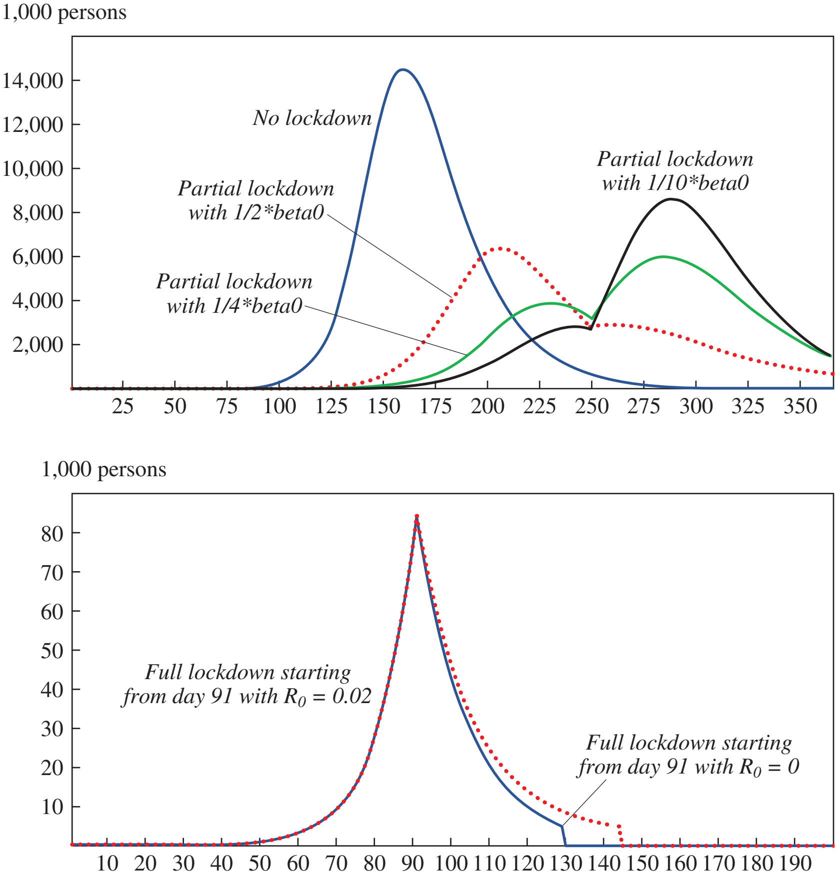


Source: Avdjiev and others (2017).

bond markets first might be because they expect higher sovereign defaults given the limited fiscal space of many EMs' governments. The reason why banking and corporate flows held stable during the COVID-19 crisis so far is probably the immense stimulus by the US Federal Reserve that increased the global US dollar liquidity, which in turn reduces the funding costs of domestic and global banks. Historical evidence shows that US monetary policy is an important driver of positive spillovers and capital inflows to EMDEs (e.g., Kalemli-Özcan 2019).

If the economic costs are larger in the short run than assumed by the authors, then the policy advice on the lockdown and containment measures may need to be revisited. The literature so far emphasizes the optimality of full lockdown policies in terms of controlling the disease as soon as possible so that infection rates go down and supply and demand normalizes (Acemoglu and others 2020; Alvarez, Argente, and Lippi 2020; Farboodi, Jarosch, and Shimer 2020; Eichenbaum, Rebelo, and Trabandt 2020). Most of the literature focuses on closed economy models and may not be appropriate for EMDEs, where full lockdowns may not be practical as argued by Goldberg and Reed. However, open economy versions of these closed economy epidemiological models show that the importance of full lockdown is even bigger as external demand is very important for EMDEs. The economic losses under partial lockdowns are higher for EMDEs (11 percent of GDP) relative to full lockdown (5.8 percent of GDP) (Cakmakli and others 2020). This is because the full lockdown recovers both domestic and external demand faster as the fear factor goes down with lower infection rates. A full lockdown controls the disease in thirty-nine days and lowers the number of deaths tremendously as shown in figure 5. This figure is adopted from Cakmakli and others (2020). The top panel shows deaths under no lockdown and each partial lockdown based on stringency or leakage. The bottom panel shows the number of deaths under full lockdown, where the version with leakage is shown with a dotted line. As shown with gray shaded areas, it takes much longer to control the disease with partial lockdowns leading to a higher number of deaths. Economic costs are larger under partial lockdowns as demand never gets normalized. These results hold even if lockdowns leak and cannot be enforced fully as typical in EMDEs. In real-time data, Goolsbee and Syverson (2020) show that no lockdowns or ending lockdowns early are not powerful tools for restarting growth so long as individuals continue to fear infection and keep demand low. Figure 5 shows the same result based on estimates from an epidemiological-economic model and shows that full lockdowns are most effective in reducing infections and so reducing

Figure 5. Number of Deaths under Full and Partial Lockdowns



Source: Cakmakli and others (2020).

the fear factor. As these full lockdowns can normalize the demand sooner, their economic costs are lower than partial or no lockdowns.

Of course, as argued by Goldberg and Reed, lockdowns are blunt policy instruments that cause social and economic damage and may not even be fully implemented in an EMDE setting with informal firms and small living spaces. Still, if lockdowns are done early enough, they can help to save lives, as shown most notably by African countries (*Financial Times* 2020). All countries need a set of policies to keep infections low after the early lockdowns as no country can keep full lockdowns forever. The only countries who have done this so far are the East Asian countries with mandated masks, strict social distancing, obsessive hygiene, testing, contact tracing, and isolating once they reopen. Most of these East Asian countries are EMDEs and are good examples of success, though for different reasons than the authors emphasize.

REFERENCES FOR THE KALEMLI-ÖZCAN COMMENT

Acemoglu, Daron, Victor Chernozhukov, Iván Werning, and Michael D. Whinston. 2020. "Optimal Targeted Lockdowns in a Multi-Group SIR Model." Working Paper 27102. Cambridge, Mass.: National Bureau of Economic Research.

Alvarez, Fernando E., David Argente, and Francesco Lippi. 2020. "A Simple Planning Problem for COVID-19 Lockdown." Working Paper 26981. Cambridge, Mass.: National Bureau of Economic Research.

Avdjiev, Stefan, Bryan Hardy, Şebnem Kalemli-Özcan, and Luis Servén. 2017. "Gross Capital Flows to Banks, Corporates, and Sovereigns." Working Paper 23116. Cambridge, Mass.: National Bureau of Economic Research.

Cakmakli, Cem, Selva Demiralp, Şebnem Kalemli-Özcan, Sevcan Yesiltas, and Muhammed A. Yildirim. 2020. "COVID-19 and Emerging Markets: An Epidemiological Model with International Production Networks and Capital Flows." Working Paper 27191. Cambridge, Mass.: National Bureau of Economic Research.

Chen, Sophia, Deniz O. Igan, Nicola Pierri, and Andrea F. Prebitero. 2020. "Tracking the Economic Impact of COVID-19 and Mitigation Policies in Europe and the United States." Working Paper 20/125. Washington: International Monetary Fund.

Eichenbaum, Martin S., Sergio Rebelo, and Mathias Trabandt. 2020. "The Macroeconomics of Epidemics." Working Paper 26882. Cambridge, Mass.: National Bureau of Economic Research.

Farboodi, Maryam, Gregor Jarosch, and Robert Shimer. 2020. "Internal and External Effects of Social Distancing in a Pandemic." Working Paper 27059. Cambridge, Mass.: National Bureau of Economic Research.

Financial Times. 2020. "Africa Needs More Help with Its Pandemic Response." July 27. https://www.ft.com/content/1af2ff7c-d9c4-47fd-972c-6a6cb2fda8dd.

Goolsbee, Austan, and Chad Syverson. 2020. "Fear, Lockdown, and Diversion: Comparing Drivers of Pandemic Economic Decline 2020." Working Paper 27432. Cambridge, Mass.: National Bureau of Economic Research.

International Monetary Fund (IMF). 2020. *"World Economic Outlook Update, June 2020: A Crisis Like No Other, An Uncertain Recovery."* Washington: International Monetary Fund. https://www.imf.org/en/Publications/WEO/Issues/2020/06/24/WEOUpdateJune2020.

Kalemli-Özcan, Şebnem. 2019. "US Monetary Policy and International Risk Spillovers." In *Economic Policy Symposium Proceedings: Challenges for Monetary Policy*. Jackson Hole, Wyo.: Federal Reserve Bank of Kansas City.

Webber, Jude. 2020. "Mexico's Economy Records Fifth Straight Quarterly Contraction." *Financial Times,* July 30. https://www.ft.com/content/1e25c567-66c3-44e0-86ed-54805a5d6503.

Wolf, Martin. 2020. "COVID-19 Will Hit Developing Countries Hard." *Financial Times,* June 9. https://www.ft.com/content/31eb2686-a982-11ea-a766-7c300513fe47.

COMMENT BY

MICHAEL KREMER Goldberg and Reed's paper makes two key claims. First, it shows that there have been fewer documented COVID-19 deaths in low- and lower-middle-income countries than in the rest of the world. Second, it argues that many of the economic costs of the epidemic are less severe than anticipated but that lockdown policies have generated large economic costs. This suggests that low-income countries may want to consider moving from blanket lockdown policies to smart containment strategies.

Understanding why there have been fewer confirmed COVID-19 deaths in low-income countries is critical for policymaking. Goldberg and Reed focus on demographics and obesity. This comment tries to draw attention to some other possible explanations with a focus on the paper's discussion of epidemiology.

Much like macroeconomists, epidemiologists typically use models and calibrate them using micro data. This paper employs a complementary approach of using cross-country data. There are advantages to combining these approaches. The findings in this paper indicate some limitations of the most basic epidemiological models. Instead, they suggest that it might be better to consider more complex models that could generate the observed data, while leading to very different policy implications.

It is useful to begin by considering the canonical epidemiological model for diseases like COVID-19, known as SIR, or the susceptible-infected-recovered model:

$$dS = -\beta IS/N$$

$$dI = \beta IS/N - \gamma I$$

$$dR = \gamma I$$

where S denotes the number of susceptible people, I denotes the number of infected people, R denotes the number of recovered people, and the total population (N) is normalized to one.

When a susceptible person meets an infected person, transmission occurs with probability β. The number of infected people grows when there is an infection event and decreases when an infected person recovers, which occurs with a rate γ (we will ignore deaths here). The change in the number of recovered people is therefore γ multiplied by the number of infected people.

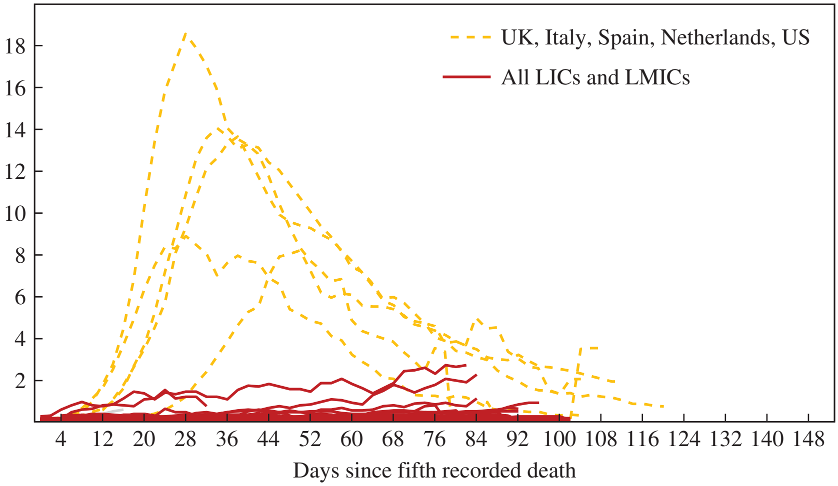
In this standard model, R_0—the number of new infections caused by an infected individual in a native population—is β/γ. If this is greater than one, the disease will spread, otherwise, the disease will not take off. We can estimate R_0 by looking at the initial doubling time (accounting for length of time between infections). For COVID-19, many studies take the data from the Wuhan province in China and the Lombardy region in Italy and estimate a relatively high rate of R_0, such as 2.5 or 3.0 (Riou and Althaus 2020; Vollmer and others 2020).

In these models, the initial growth is close to exponential, but later there are fewer susceptible people, and therefore infected individuals are less likely to meet and infect the susceptible ones. The epidemic slows down and eventually reaches the stage of herd immunity, when $1/R_0$ people are susceptible. Still some transmission still happens beyond this point, but the disease starts to die off. An R_0 of 2.5 suggests that 60 percent of the people will need to be infected before the disease slows down. This indicates a fairly pessimistic picture for the pandemic.

The next question is how to include mortality in the model. One possibility is to allow the total deaths to be equal to the number of people who are ever infected multiplied by the infection-fatality rate. We know from micro data that elderly people and obese people are more likely to succumb to COVID-19. Looking at the difference in death rates by demographics using Chinese data (Verity and others 2020), we would expect a fivefold difference between developed countries and low-income countries in mortality solely based on the fact that there are less elderly people in very poor countries.[1] While differences in obesity prevalence might strengthen this effect, there could be factors increasing the mortality in poorer countries, such as weaker health systems or higher air pollution. So, it is reasonable to expect roughly a fivefold difference. However, the actual

1. We reweighted the Chinese estimates of age-specific mortality (Verity and others 2020) by age distribution in other countries based on the 2019 UN World Population Prospects, assuming all age groups have the same infection rate. The infection-fatality rate then ranges from an average of 0.25 percent in low-income countries to 1.24 percent in high-income countries.

Figure 1. Daily COVID-19 Deaths per Million Inhabitants



Source: Lea (2020).
Note: LICs are low-income countries; LMICs are lower-middle-income countries.

differences are much larger (see figure 1). The death rate in the United Kingdom is almost fifty times greater than the death rate in low- and middle-income countries.

The main regressions in the paper focus on cumulative deaths. However, it is possible to extract more information by taking advantage of the time path in mortality. One can observe much flatter curves for low- and lower-middle-income countries compared to OECD countries. The rapid exponential growth seen in high-income countries has not been replicated in low- and middle-income countries. If this was driven solely by a lower fatality rate, we would have the same shape of the curve, but it would be one-fifth as large at any point. However, the curve appears to have a different shape and a different trajectory, which cannot be explained by differences in the death rate alone. One could argue that demographics affect the infection rate, but this would probably go the opposite way; older people probably go out less and hence are less likely to contract the virus.

One reason for a lower curve could be that the demographics and mortality rate may be working differently in different countries. In India, Mexico, and South Africa the share of deaths among the elderly is lower than in high-income countries, even after adjusting for demographics. The difference is quite stark with 90 percent of deaths in the United Kingdom among the elderly to just over 50 percent (ranging from 51 percent to 65 percent after reweighting by demographic structure) in India, Mexico, and South Africa.[2] It would be interesting to further explore the hypothesis that in low- and middle-income countries other risk factors not found in the high-income countries may be driving mortality. A competing explanation is that deaths are underreported in the older population in low- and middle-income countries relative to high-income countries. However, this would make the curve lower but would not explain it being flatter.

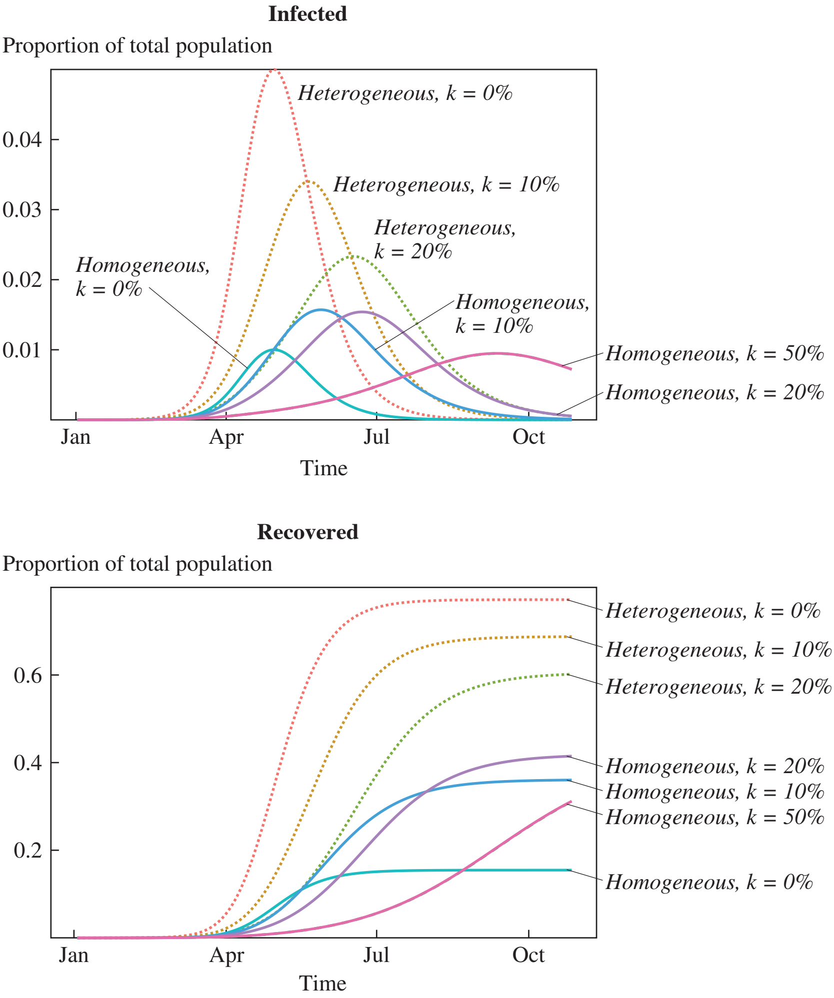
Another possible reason for the curve being lower in low- and middle-income countries is measurement error. However, as Goldberg and Reed argue, the effect seems too large to be explained solely by this. In addition, for measurement error to explain the flatness as well as the height of the curve, there would need to be an implausible downward trend in the fraction of reported COVID-19 deaths. While it is plausible that in low-income countries many COVID-19 deaths are not attributed to the virus, it is harder to explain why the fraction of reported COVID-19 deaths would decline over time.

Another explanation could be a shorter gap between the epidemic arriving and lockdown measures. Under a standard epidemiological model, assuming the contact rates return to normal after a lockdown, countries will move toward herd immunity just as they would in the absence of a lockdown. That does not seem to be happening in low- and middle-income countries. There is considerable uncertainty in the data so we should be cautious, and there are more complex stories one could tell. However, if we take the data in this paper, the policy variables do not seem sufficient to explain the results.

I suggest an alternative, speculative hypothesis. There are many reasons to think that epidemiological parameters might be heterogeneous across communities. There are high-risk places such as meatpacking plants. People who are regularly present in those places are therefore at higher risk. We also know that there are factors affecting transmission that are

2. See United Nations Department of Economics and Social Affairs, "2019 Revision of World Population Prospects," https://population.un.org/wpp/; United Kingdom Office for National Statistics, "Deaths Registered Weekly in England and Wales, Provisional," up to week ending August 28, https://www.ons.gov.uk/peoplepopulationandcommunity/birthsdeathsandmarriages/deaths/datasets/weeklyprovisionalfiguresondeathsregisteredinenglandandwales, accessed September 4, 2020; Indian Ministry of Health and Family Welfare, "Updates on COVID-19," press release, May 21, https://pib.gov.in/PressReleseDetail.aspx?PRID=1625744; and Secretaría de Salud de México, "Información Referente a Casos COVID-19 en México" [database], https://datos.gob.mx/busca/dataset/informacion-referente-a-casos-covid-19-en-mexico, accessed September 4, 2020.

Figure 2. Heterogeneous versus Homogeneous Models: An Example



Source: Author's calculations.

correlated with income, such as temperature, home ventilation, time spent outdoors, and the patterns of social interaction. So, let us consider a model with different types of subcommunities and limited interaction across these groups. Imagine, for example, there is a high transmission subcommunity that is 20 percent of the population with an R_0 of 2.6 and a low transmission subcommunity with an R_0 of 0.8.

Under the canonical SIR models, the epidemic will take off in the region where R_0 is 2.6 but not in the subcommunity where R_0 is 0.8. The overall R_0 for the country would be close to 2.6, leading to the conclusion that between 60 and 70 percent of the population will need to be infected before herd immunity can be reached. In fact, only 60 percent to 70 percent of the high R_0 communities would be infected before herd immunity is reached. This is consistent with some of the data we see, without necessarily implying that policy played a key role.

In a world with heterogeneity, the optimal policy is very sensitive to parameters. For example, let us assume that governments can put in place containment measures that generate economic costs but cut the rate of spread by 25 percent. If the high R_0 groups have already reached herd immunity and R_0 in the low spreader group is less than one, containment measures are unnecessary. On the other hand, if the low transmission group has an R_0 of 1.2 without containment policies, relaxing the containment measures would enable further spread.

It is important to add that the high heterogeneity in R_0 and behavior change are not the only two hypotheses that can account for a lower herd immunity threshold. There is some evidence of susceptibility to the disease being much lower in children than in adults and the elderly. One recent estimate of the susceptibility of children (Davies and others 2020) is that it is half of that in adults. It could be that children do get sick just as easily as the adults but experience a very different course of the disease. There is even a possibility that many of them are immune. The hypothesis of preexisting immunity has been raised by other recent papers (Le Bert and others 2020). If it is true, it would also lead to a lower herd immunity threshold.

The competing hypotheses mentioned are not easy to distinguish from each other using macro, summary-level data of the type we are discussing here, especially given the inherent biases and various forms of under-reporting. All these hypotheses indicate that the growth rate of the epidemic will decrease over time, earlier than what a simple epidemiological model would predict. But at a minimum, we can still use these data to quantify the extent of departure from "simple" epidemiological models (in which we account for demographics, obesity, government policy, etc.) and if such a discrepancy occurs, evaluate whether it varies from country to country.

One cause for possible optimism is that we often talk about lockdown measures as a binary variable, when there are in fact many different policies that vary in their likely impacts on the spread of the disease, as well as in their economic, social, and overall health impacts. There are some fairly low-cost measures, like wearing masks or restrictions on nightclubs where the virus spreads easily. On the other hand, there are measures like shutting down trade or childhood immunization, both of which have very high economic or social costs while not doing much to prevent the spread of the epidemic.

If there is a lot of uncertainty about the model and about the parameters, repeated prevalence surveys could be used to track the epidemic over time. With these, one could progressively relax the restrictions with the lowest epidemiological risks and the highest economic benefits. It would require monitoring the growth rate of infections throughout this process and applying stricter restrictions if it approaches one.

This approach makes sense for an individual country trying to control the epidemic, and allows us to learn during the process. The hypothesis that heterogeneity in epidemiological parameters could explain the lower prevalence in low- and middle-income countries is one of many, and there is not yet strong evidence to support it. However, prevalence surveys could reveal patterns suggesting that, for example, rural areas of low-income countries have an R_0 below one even without containment. In that case, a policymaker could adopt fairly relaxed policies in those areas. On the other hand, for dense or low-income urban populations, it could be the case that R_0 is greater than one unless there are containment policies in place, in which case we do need those restrictions.

It is important to mention that while COVID-19 has brought devastating consequences on its own, containment policies can also cause a huge burden to the population. It is essential to understand where and in which situations the containment policies are necessary, as well as which policies are the most effective. By using real-time data from representative prevalence surveys to inform our decisions, we can choose policies that are capable of bolstering the recovering economies while avoiding the economic and social consequences of blanket lockdowns. At the same time, we also need to ensure that these policies are effective in preventing an unacceptable spread of the disease.

REFERENCES FOR THE KREMER COMMENT

Davies, Nicholas G., Petra Klepac, Yang Liu, Kiesha Prem, Mark Jit, CMMID COVID-19 Working Group, and Rosalind M. Eggo. 2020. "Age-Dependent Effects in the Transmission and Control of COVID-19 Epidemics." *Nature Medicine* 26:1205–11. https://doi.org/10.1038/s41591-020-0962-9.

Le Bert, Nina, Anthony T. Tan, Kamini Kunasegaran, Christine Y. L. Tham, Morteza Hafezi, Adeline Chia, and others. 2020. "SARS-CoV-2-Specific

T Cell Immunity in Cases of COVID-19 and SARS, and Uninfected Controls." *Nature* 584:457–62. https://doi.org/10.1038/s41586-020-2550-z.

Lea, Nick. 2020. "State of the COVID-19 pandemic, 24th June 2020." Unpublished presentation. London: Foreign, Commonwealth and Development Office.

Riou, Julien, and Christian L. Althaus. 2020. "Pattern of Early Human-to-Human Transmission of Wuhan 2019 Novel Coronavirus (2019-NCoV), December 2019 to January 2020." *Eurosurveillance* 25, no. 4. https://doi.org/10.2807/1560-7917.ES.2020.25.4.2000058.

Verity, Robert, Lucy C. Okell, Ilaria Dorigatti, Peter Winskill, Charles Whittaker, Natsuko Imai, and others. 2020. "Estimates of the Severity of Coronavirus Disease 2019: A Model-Based Analysis." *Lancet Infectious Diseases* 20, no. 6: 669–77. https://doi.org/10.1016/S1473-3099(20)30243-7.

Vollmer, Michaela, Swapnil Mishra, H. Juliette T. Unwin, Axel Gandy, Thomas A. Melan, Valerie Bradley, and others. 2020. *Report 20: A Sub-National Analysis of the Rate of Transmission of COVID-19 in Italy*. London: Imperial College COVID-19 Response Team. https://doi.org/10.25561/78677.

GENERAL DISCUSSION Daron Acemoglu followed up on Michael Kremer's comments, noting that heterogeneous infection rates across groups have major implications for the spread of diseases and that these implications can be difficult to untangle. He stated that the R_0 values estimated at the beginning of an infection event tend to be inaccurate because high-R_0 groups generally get infected first and then recover, resulting in different infection patterns during subsequent periods. Acemoglu continued by stating that density is a huge determinant of R_0 values, noting the cases of severe COVID-19 spread in New York City and London. In contrast to these cases, he pointed out that in many EMDEs, much of the population lives in lower-density areas, which will be a major determinant of how the COVID-19 pandemic unfolds in these countries.

Pinelopi Goldberg responded by addressing some of the issues with data brought up during Şebnem Kalemli-Özcan's and Kremer's comments and alluded to by Acemoglu. She stated that while it is likely that the number of deaths in EMDEs is undercounted, comparing the COVID-19 death curves in EMDEs to those in advanced economies in figure 2 reveals that the curves are entirely different shapes, not just at different levels. As undercounting would lead to similarly shaped but lower curves, this difference in curve shapes suggests that the low number of reported deaths in EMDEs is not solely due to data issues. Goldberg went on to emphasize that there still needs to be more testing. She stated that there are currently major issues with the data on number of cases by country, as these data are driven mostly by the number of tests done in a country, not by actual patterns of COVID-19 cases.

In response to Acemoglu's initial comments, Goldberg then pointed out that the paper controls for the population density of the largest urban center in each country and that this variable was included in the preferred specification along with age, obesity, and time since first death. She noted that it could be fruitful to explore a specification including variables for both the density of the largest urban center in a country and the density of the entire country. Goldberg also stated that it would be of interest to further examine the impact of the time since first death variable and that, overall, more granular data would be useful. In response to Kremer's comments regarding epidemiological modeling, Goldberg stated that there has been substantial pushback against modeling during this pandemic because many models have had significant shortcomings and have needed to be revised.

Regarding Acemoglu's comments on density, Tristan Reed remarked that his and Goldberg's analysis explored both the density of the largest urban city in a country and the density of the entire country in different specifications, and the density of the largest urban city had greater predictive power. He then explained that in the specification that included GDP per capita, time since first death, age, obesity prevalence, and urban density, the coefficient on GDP per capita became significant and rose in comparison to the specification including only GDP per capita, time since first death, age, and obesity prevalence. This means that EMDEs have fewer cases despite having high urban density, rather than *because of* low density.

Goldberg then speculated on the effects of various government policies meant to counteract the spread and severity of the pandemic. Despite the analysis finding no significant effect of early policy response on deaths from COVID-19, she stressed that her takeaway was not that policy is unimportant but that the nuanced effects of policies were not captured in current data. She described as examples the cases of Vietnam and Peru. At the time of discussion, June 25, Vietnam had zero deaths from COVID-19 despite sharing a border with China, due in part to effective policies that imposed checks on travelers early in the pandemic and managed to prevent the spread of the virus. In contrast, Peru also adopted policies to address the pandemic relatively quickly, but the virus spread widely regardless, perhaps due to slums and a large informal sector that made policies ineffective. Goldberg argued that these two cases show that policy implementation, rather than just policy adoption, had the most impact on reducing the spread and severity of COVID-19 within countries. Implementation, however, is not captured in their quantitative data.

Kalemli-Özcan pointed out that, in regards to government policies, partial lockdowns have potentially higher annual costs than full lockdowns because partial lockdowns tend to last longer since infection rates remain higher than in a full lockdown. She continued by saying that changes to demand will have a large impact on costs of the pandemic and that external demand in particular will be extremely important for some EMDEs. Furthermore, Kalemli-Özcan argued that current debt relief policies will be ineffective at alleviating economic hardships in many EMDEs because many of these countries have substantial debt owed to private creditors, who are not included in relief policies. Instead, she posited that capital outflows will be more important for EMDEs than their debt stock, as it will be harder to roll over the debt with private creditors during increased capital outflows, an argument she also expanded on in her earlier comment.

Marianne Bertrand then shared her thoughts on large urban centers in EMDEs, stating that her intuition was that these areas should have the largest numbers of deaths due to COVID-19. She asked why the results found in the paper seemed to go against this intuition, with EMDEs experiencing fewer deaths from COVID-19 despite having large, dense urban centers. Goldberg agreed that the results went puzzlingly against intuition and responded by stating that she and Reed had no definitive answer for this trend. Kremer suggested that, because being outdoors seems to substantially reduce transmission of the virus, deaths may be lower in EMDEs despite the density of urban areas because buildings, especially in warm-climate areas, may be highly ventilated. People in these countries may also spend more time outdoors, again due to temperature. He also stated that temperature itself may have some impact on the transmissibility of the virus, but findings in this area of research are mixed.

Raquel Fernández suggested that the extent and use of public transportation might be an important explanatory factor for this urban density trend and asked whether the authors had explored this as a variable. Goldberg responded that she and Reed had not included a public transportation variable, as no global data exist for public transportation. Instead, they explored a variable for change in mobility and found an effect on deaths with the inclusion of this variable. Reed specified that the mobility data come from Google. Kalemli-Özcan stated that it was important to note that the Google mobility data only cover people with phones connected to Google and that there is therefore less data coverage in EMDEs, where many people may not have smartphones or use Google.

Kalemli-Özcan continued by emphasizing the importance of looking at gross capital flows to understand the economic impact of crises, as she stated in her earlier comments. Goldberg responded that while the focus on gross capital flows provides some interesting opportunities for analysis, she and Reed also focused on other measures of economic impact, including net capital flows and commodity prices. Her takeaway from their analysis of these measures is that the COVID-19 economic shock is comparable to previous crises and that the economic shock to EMDEs is likely to play out through familiar channels.

Kalemli-Özcan then spoke on the importance of global policy coordination to ensure that the economic impact of COVID-19 will not be catastrophic. Goldberg agreed with this but pointed out that there is little global willingness to help EMDEs. Instead, the global economic shock of COVID-19 has provided countries with an excuse to focus on domestic economies. Because of this current lack of external help and global coordination, in the long term, she and Reed are pessimistic about economic recovery in EMDEs.

Reed continued by arguing that at the start of the pandemic, a major concern was that EMDEs would need to spend massively to respond to the virus and support locked down populations and that few countries had the fiscal space to do so. However, if the infection rate is lower in EMDEs, as his and Goldberg's paper suggests, this massive amount of expenditure may not be necessary. Reed emphasized that fiscal space remains a concern. Recent debt standstills will help some in this regard, and he argued that there is still time for bond markets to return to normal and expand the borrowing capacity of EMDEs.