CESifo WORKING PAPERS

8425
2020

July 2020

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Aziz N. Berdiev, Rajeev K. Goel, James W. Saunoris

CESifo

Impressum:

CESifo Working Papers
ISSN 2364-1428 (electronic version)
Publisher and distributor: Munich Society for the Promotion of Economic Research - CESifo GmbH
The international platform of Ludwigs-Maximilians University's Center for Economic Studies and the ifo Institute
Poschingerstr. 5, 81679 Munich, Germany
Telephone +49 (0)89 2180-2740, Telefax +49 (0)89 2180-17845, email office@cesifo.de
Editor: Clemens Fuest
https://www.cesifo.org/en/wp
An electronic version of the paper may be downloaded
· from the SSRN website: www.SSRN.com
· from the RePEc website: www.RePEc.org
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CESifo *Working Paper No. 8425*

International Disease Epidemic and the Shadow Economy

Abstract

Adding to the emerging body of research related to the current coronavirus crisis, this paper studies the impact of disease epidemics on the worldwide prevalence of the shadow or the underground economy. The informal sector undermines compliance with government regulations and lowers tax collections. Our main hypothesis is that epidemics positively impacts the spread of the shadow economy. Using data on nearly 130 nations and nesting the empirical analysis in the broader literature on the drivers of the shadow sector, we find that both the incidence and the intensity of epidemics positively and significantly contribute to the spread of the underground sector. Numerically, a ten percent increase in the intensity of epidemics leads to an increase in the prevalence of the shadow economy by about 2.1 percent. These findings about the spillovers from epidemics have implications for economic policies in the current times of coronavirus.

JEL-Codes: I150, K420.

Keywords: shadow economy, epidemics, COVID-19, government, economic development.

Aziz N. Berdiev
Bryant University / Smithfield / RI / USA
aberdiev@bryant.edu

*Rajeev K. Goel**
Illinois State University / Normal / IL / USA
rkgoel@ilstu.edu

James W. Saunoris
Eastern Michigan University / Ypsilanti / MI / USA
jsaunori@emich.edu

*corresponding author

1. Introduction

Economics research on the impacts of disease epidemics has existed for some time (Adda (2016), Becker (1990), Prior and Stanhope (1980)).[1] These issues have again come to a head with the recent and ongoing events related to the COVID-19 virus. Whereas various disciplines are grappling with the unexpected scale and scope of the challenges unleashed by the coronavirus, there are some longer-term and less immediate consequences that are not on the front burners of researchers' and policymakers' concerns. Yet, some of these impacts could persist over time and have adverse spillovers on other activities, making it important that attention is devoted to the understanding of their influence early on.

This paper focuses on one such possible impact of epidemics – the worldwide prevalence of the shadow economy.[2] The shadow economy (also called the informal, underground or black market) persists in all nations of the world, with variations in its scope (Medina and Schneider (2017); Schneider and Enste (2013); Schneider et al. (2010)), as individuals and firms try to evade regulations and taxes. The presence of the informal sector is challenging for governments both because it undermines tax collections on the one hand, and adherence to regulations and laws, on the other hand. Examples of shadow activities abound including under-reported income by businesses, repairs by unlicensed contractors, smuggling of contraband, etc. Given its importance and wide prevalence, a substantial body of work has emerged on the causes or drivers of the underground sector (see Gërxhani (2004), Goel and Nelson (2016), and Schneider and Enste (2000) for literature surveys). Within this spectrum of possible determinants of the

[1] The World Health Organization defines an epidemic as: "The occurrence in a community or region of cases of an illness, specific health-related behavior, or other health-related events clearly in excess of normal expectancy" (https://www.who.int/hac/about/definitions/en/).
[2] The shadow economy captures economic activity that is unregistered in the official economy (see Schneider et al. (2010) for details).

shadow economy, the influence of disease epidemics has not been considered and forms the focus of this work.

Specifically, we use worldwide data to see how disease epidemics impact the shadow economy, considering both the incidence and intensity of epidemics. About fourteen percent of the nearly 130 nations in our sample, faced a biological epidemic from 1991-2015 (www.cred.be; Table 1 and 1A). While the underlying source of the disaster data has broad information on natural and technological (manmade) disasters (The Centre for Research on the Epidemiology of Disasters (CRED (www.cred.be)), we chose to focus on biological epidemics because such disasters have direct relevance to the current COVID-19 crisis.[3] Another advantage of obtaining the data from a single source is that the disasters are consistently coded (and not prone to media focus on only large disasters).

Adding to the emerging body of research related to the current coronavirus crisis (Baldwin and Weder di Mauro (2020)), this paper studies the impact of disease epidemics on the worldwide prevalence of the underground economy. Due to the breakdown of efficient institutions and a sudden loss of employment, individuals and firms are likely to find the move to the underground sector attractive. The breakdown of institutions or a shift in government's focus away from enforcement to finding a cure for the epidemic, lower the potential costs of underground operations, while the unemployed find easier entry into the informal sector. This is especially true when epidemics temporarily close some of the training centers for the unemployed to retrain and reenter the formal labor force.

[3] Specifically, CRED defines biological disasters as, "A hazard caused by the exposure to living organisms and their toxic substances (e.g. venom, mold) or vector-borne diseases that they may carry. Examples are venomous wildlife and insects, poisonous plants, and mosquitoes carrying disease-causing agents such as parasites, bacteria, or viruses (e.g. malaria)", https://www.emdat.be/classification.

If it turns out that epidemics end up increasing the shadow sector, there would be a consequent downward impact on governments' efforts to contain epidemics both via a resource constraint (low tax collections) and a lessened ability to monitor compliance with health and safety regulations. Moreover, to the extent that individuals are evading stay-at-home orders and participating in the shadow economy, this may undermine efforts to contain the spread of the disease.

Key questions addressed in this research are:

- Does the prevalence of disease epidemics significantly impact the prevalence of the shadow economy?
- Are the impacts of the incidence and the intensity (diffusion) of epidemics on the shadow economy similar?

Besides answering the above questions using time series data for over 125 nations, the analysis will draw recommendations for related policies in the times of coronavirus (https://www.weforum.org/agenda/archive/covid-19). Placing the formal empirical analysis within the significant cross-national determinants of the shadow economy, our results show that both the incidence and the intensity of epidemics increase the shadow economy. These findings withstand a series of robustness checks.

The structure of the rest of this paper includes the literature review and hypothesis in the next section, followed by the empirical model, data, results, and conclusions.

2. Theoretical discussion and hypothesis

In this paper, we are interested in understanding the shadow economy's response to biological disasters classified as epidemics. The onset and spread of epidemics are largely uncertain so broadly speaking, one could view the analysis in the context of a shock to the economy, with both macro and micro implications. In the context of the shadow economy – epidemics relation, one could view the macro impacts being on institutions and government resources, whereas the micro impacts would be individuals' health and employment. All of these potentially impact propensities to operate in the underground sector.

In particular, there are numerous channels through which one could envision how epidemics could impact the underground sector (https://medicalxpress.com/news/2020-05-coronavirus-response-isnt-billion-people.html). One, epidemics impact the smooth functioning of government institutions – both devoted to enforcement of rules and awarding of punishments. This emboldens potential lawbreakers, with their potential net benefits from breaking the law increasing (see Becker (1968)). Two, government efforts to contain the spread of viruses create regional "islands" that are somewhat autonomous, again presenting opportunities for some to evade paying taxes or adhering to regulations. These pockets or islands are not necessarily created by geographic distances but might be the result of governments favoring certain areas of high virus prevalence (e.g., capital cities). Breakdowns in communications networks following epidemics might also result in such isolated areas. The presence of such pockets might engender barter transactions, which cannot be traced by tax officials. Third, in times of crises posed by epidemics, market functions are disrupted, providing opportunities for entry to unauthorized or shadow agents. Anecdotal evidence exists under the current COVID-19 crisis with instances of unauthorized (home) barber shops, in-home informal tuitions, unauthorized ambulance or taxi services, etc.

Furthermore, the counter-cyclical relationship between shadow economies and formal sector business cycles, as shown by Elgin (2013), is likely to exist as epidemics depress the formal sector. Shadow economies serve as an economic buffer to absorb the over- or under- capacity of the formal sector. During economic recessions, the shadow economy offers an attractive alternative for earning income among unemployed individuals, especially to prevent losing unemployment insurance benefits. In other words, unemployed individuals might prefer to work in the shadow sector in order to earn additional income that is concealed from the government. Whereas Raddatz (2007) provides evidence that epidemics lower formal economic activity, we argue that epidemics might drive individuals to the shadow economy. It is perhaps expected that the underground economy provides refuge for individuals who lose formal sector employment (see, e.g., Dell'Anno and Solomon (2008); Bajada and Schneider (2009)).

One could also argue that the demand for goods and services in the shadow economy might rise during epidemics as economic participants are more likely to purchases goods and services in the shadow economy since they are, on average, less costly than formal sector goods and services and of similar quality (Schneider and Enste (2013)). Additionally, the shutdown implemented by governments following epidemics might make certain formal sector goods and services unattainable, thereby inducing shadow participants to step in to meet these demands.

Another reason might be that firms may partially or fully transition to the underground sector in order to save resources and or cut costs. Indeed, during the current COVID-19 pandemic, small businesses are deciding to defy government orders to remain closed, and instead are continuing to serve their customers.[4] Furthermore, increased demand combined with anti-price gouging laws that result in shortages of necessary goods and services during epidemics (e.g., face masks, disinfectants, etc.) offer unique opportunities for budding shadow entrepreneurs. All

[4] https://www.bloomberg.com/news/articles/2020-05-18/rogue-businesses-go-underground-as-covid-black-market-takes-off.

of these reasons suggest that the incidence and spread of epidemics might drive individuals and businesses to the shadow economy.

In addition to the tie to the shadow economy literature, this work also adds to the economics of epidemics (Adda (2016), Kahn (2005), Ma et al. (2020), Rasul (2020)), or more broadly, to the effects of macroeconomic shocks (Nov (2009)). This body of work, with a renewed focus on COVID-19 in recent months (see Baldwin and Weder di Mauro (2020), Jordá et al. (2020)), has in the past mostly focused on the impacts of specific epidemics and/or specific regions (Armien et al. (2008), Bloom and Mahal (1997), Folgi and Veldkamp (2019), Hasala et al. (2012), Prior and Stanhope (1980)). The broad consideration of various epidemics over time in regard to their impact on the underground economy is unique to this work.

Based on the above discussion, we frame our main hypothesis that we test using annual data from a large set of nations:

H1: Greater prevalence of disease epidemics would increase the shadow or the underground sector.

To test hypothesis H1, we consider the impact of both the incidence and severity of epidemics on the shadow economy. Given the current COVID-19 crisis, and the worldwide development of the shadow economy, understanding the spillovers from epidemics on underground economic activity could have important implication for current economic policies. We turn next to the empirical model and data.

3. Empirical model and data

3.1. Empirical model

To test the above hypothesis and to focus on the key influence of epidemics, the general model to explain the size of the shadow economy for country *i* and time *t* is:

$$Shadow_{\mathrm{it}} = \mathrm{f}\left(Epidemic_{\mathrm{itm}}, ECgrowth_{\mathrm{it}}, Freedom_{\mathrm{itg}}, Government_{itk}\right) \quad (1)$$

where

i = 1,…,129

t = 1991,…,2015

m = *EpidemINC*, *EpidemDIFF*

g = *PolFreedom*, *EconFreedom*

k = *BureauQual*, *GovtSize*

The dependent variable is the size of the shadow economy as a percent of GDP (*Shadow*). This variable is estimated by Medina and Schneider (2017) for 158 nations from 1991 to 2015. In this paper, we posit that the occurrence of epidemics in countries related to infectious diseases (i.e., bacterial, viral, fungal, and prion) has an important influence on the decision for individuals and firms to move underground. To account for this unique aspect, we include two variables that capture the incidence of the epidemics (*EpidemINC*) and also the diffusion of epidemics (*EpidemDIFF*). In other words, we account for both the occurrence and the severity, or intensity, of the epidemic on its impact on the shadow economy.

The baseline models, which alternatively include *EpidemINC* and *EpidemDIFF*, are estimated using OLS and including regional fixed effects to account for region-specific characteristics that influence the shadow economy.

In order to isolate the impact of epidemics on the shadow economy, we borrow from the extant literature and control for a variety of other factors that influence the size of the shadow economy (Gërxhani (2004); Goel and Nelson (2016); Schneider and Enste (2000)). In particular, we account for formal economic growth (*ECgrowth*) to account for the health of the formal sector economy, the degree of freedom measured as political (*PolFreedom*) and economic (*EconFreedom*), and the quantity, or size, of government (*GovtSize*) and the quality of government (*BureauQual*). Strong economic growth in the formal sector raises the opportunity cost of producing underground. Greater political freedom gives the power of voice in encouraging elected officials to behave in a favorable way and reduce the need to exit to the underground sector. Likewise, more economic freedom (e.g. low taxes and regulations) in the formal sector diminishes the relative benefits of the underground economy relative to the formal economy (Berdiev et al. (2018)). The strength and quality of institutions, proxied by bureaucratic quality, improve the workings of the formal sector and thus reduce the impetus for underground activities (Dreher et al. (2009); Torgler and Schneider (2009); Berdiev et al. (2020)). Lastly, the size of government can have various impacts including promoting the development of the shadow economy if the long arm of the government encourages people to move underground, or decreasing the size of the shadow economy if the government uses its resources to combat shadow activities (Goel and Nelson (2016)).

3.2. Data

The data set is a panel of 129 countries observed annually from 1991 to 2015 – see Table 1A for a list of countries used in the analysis. The data is constrained by the dependent variable capturing the size of the shadow economy from Medina and Schneider (2017) that is available only from 1991 to 2015. Still, the period of the analysis is instructive for framing policies in times of the current coronavirus crisis.

The clandestine nature of the underground economy necessitates creative ways to uncover their activities (see Schneider and Buehn (2013) for a review). One technique used to measure the size of the shadow economy that has gained popularity is the multiple indicators, multiple causes (MIMIC) method (Schneider et al. (2010)). The MIMIC method uses covariance information from several observable causal and indicator variables to estimate the latent shadow economy. Specifically, the MIMIC method is a structural equations model that is comprised of two equations, the structural model that links the causal variables to the shadow economy, and the measurement model that links the shadow economy to the indicator variables. Our measure of the shadow economy comes from Medina and Schneider (2017) who use the MIMIC method to provide the most recent estimates of the shadow economy for a large panel of nations. This estimate of the shadow economy is an improvement on the widely used measure of the shadow economy from Schneider et al. (2010). According to this estimate of the shadow economy, the average size of the shadow economy is approximately 32% of GDP with considerable variation across countries, with a high of 72% (Georgia) and a low of 8% (Switzerland).

Data on epidemics related to biological disasters is from the Emergency Events Database (EM-DAT) from the Centre for Research on the Epidemiology of Disasters (CRED, www.cred.be). This database, which has been utilized extensively by prior studies (see, e.g., Kahn (2005), Raddatz (2007) and Noy (2009)), includes epidemics related to infectious diseases including viral, bacterial, fungal, and prion from 1900 to 2020 for 160 countries. According to this data set, approximately 57% of epidemics are bacterial disease, 40% are viral disease, and 3% are parasitic disease. Among the most common epidemics were caused by Cholera, Dengue, and Meningococcal disease. Based on the start and end date of each epidemic identified in this database for each country, we create a dummy variable (*EpidemINC*) that is equal to one for the years the epidemic occurred and zero otherwise. To capture the severity of the epidemic, we also consider the number of people affected (*EpidemDIFF)*, which includes 100 or more people that are affected, injured or homeless as a result of the epidemic.[5] Due to the number of zeros in the number affected, we transform this variable by adding one to all observations and then dividing this by population (in millions) and then take the natural log.[6] The Democrat Republic of the Congo and Niger experienced the highest incidence of epidemics over the 1991-2015 time period and Niger also had the most affected cases. Also, the correlation between *Shadow* and *EpidemINC* and *EpidemDIFF* is approximately 0.24.

The other variables used in the analysis are from reputed international sources that are routinely used in the literature. Complete details about variable definitions, summary statistics and data sources are provided in Table 1.

4. Results

4.1. Baseline results

We test the impact of *EpidemINC* and *EpidemDIFF* on the shadow economy and present the baseline regression estimates in Models 2.1 and 2.2 of Table 2, respectively. This enables us to verify the validity of hypothesis H1.

The results show that the coefficient on *EpidemINC* is positive and statistically significant at the 5% level, thereby suggesting that the presence of epidemics increase the size of the shadow economy. Epidemics prompt individuals and firms to move underground as a means to maintain operations and earn income. Furthermore, during epidemics, the focus of nations likely shifts away from controlling the shadow economy, which lowers the expected costs of operating

[5] The number of deaths caused by the epidemic is another potential measure of the severity; however, a deadlier disease is one that has less time to spread. Therefore, we prefer to use the number affected to capture severity and likely has a more direct impact on the spread of the shadow economy.
[6] Similar transformations have been used by the extant literature (see, e.g., Kahn (2005) and Healy and Malhotra (2010)).

underground. Numerically speaking, the occurrence of an epidemic increases the size of the shadow economy by 1.32 percentage points. This finding thus confirms our hypothesis H1 that epidemics are positively linked with shadow development.

Next, we turn to assess the severity of epidemics on underground participation. This consideration enables us to account for nations that are dissimilarly impacted by epidemics. The coefficient on *EpidemDIFF* is positive and statistically significant at the 1% level. These findings imply that nations that have more individuals affected by epidemics experience a larger underground sector. Besides the reasons mentioned above, with a large diffusion of the disease, networking and demonstration might play a role in inducing movement underground. Furthermore, the onset of epidemics might induce migration by some of the people in affected areas, and this might contribute to the underground sector (Goel et al. (2020)). In terms of magnitude, the underground economy increases by about 2.1 percent with a 10 percent increase in the number of individuals affected (per million population). These results continue to highlight that the occurrence of an epidemic and the severity (or intensity) of the epidemic promote shadow sector activities.

Turning to the control variables, the coefficients on *ECgrowth*, *BureauQual*, and *EconFreedom* are negative, whereas the coefficient on *PolFreedom* is positive, all at the 1% level of significance. As expected, prosperous countries have strengthened enforcement and higher opportunity costs of operating underground. Furthermore, the quality of government bureaucracy, and institutions that support policies to promote economic freedom curb underground participation. Greater political freedom or a higher degree of democracy is tied to a due legal process, which is often lengthy. This delay lowers the expected value of punishment for operating underground.

The coefficient on *GovtSize* is negative and statistically significant at the 1% level. This suggests that nations with larger governments have a lower incidence of shadow activity. This is consistent with the notion that a larger government also has some resources devoted to enforcement, which lowers the prevalence of the shadow economy. Overall, the results for the control variables are broadly consistent with the literature (e.g., Dreher et al. (2009); Goel and Nelson (2016); Berdiev et al. (2018)).

To tests the validity of our results, we conduct several robustness checks to account for the following: the potential impact of outliers, the possible simultaneity between epidemics and the shadow economy, additional control variables, and the potential simultaneity between economic growth and the shadow economy. Furthermore, we also address potential heterogeneity by splitting the sample into non-island, non-OECD and OECD nations. The regression estimates for the robustness checks are reported in Models 2.3-2.8 of Table 2, Tables 3 and 4.

4.2. Considering additional control variables

As our first robustness check, we account for additional control variables, namely, the strength of the rule of law (*RuleLaw*), the unemployment rate (*UNEMP*) and the level of education (*EDUC*). A consistent rule of law increases the potential punishments for breaking the law and we would expect nations with a strengthened rule of law to have a smaller shadow economy, ceteris paribus (e.g., Torgler and Schneider (2009); Dreher et al. (2009)). Greater educational attainment promotes understanding and adherence to the laws, while making entry into the formal labor force easier (e.g., Loayza et al. (2009); Berdiev and Saunoris (2018)). Both of these factors would check the informal sectors. Finally, the unemployed have a higher propensity to enter the informal sector (e.g., Dell'Anno and Solomon (2008); Bajada and Schneider (2009)).

We add these additional control variables one at a time to our baseline models and report the results in Table 2, Models 2.3-2.8. First of all, the positive impact of epidemics on the shadow economy that was shown in the baseline models, remains and is statistically significant for both *EpidemINC* and *EpidemDIFF* in all models. Thus, both the incidence and the intensity of epidemics contribute to the spread of shadow operations, and these results withstand the inclusion of additional covariates.[7]

Furthermore, the results for unemployment and education are consistent with intuition (albeit fail to gain statistical traction at conventional levels of significance) – greater educational attainment reduces the size of the shadow economy (Models 2.7-2.8), while greater unemployment has the opposite effect (Models 2.5-2.6). The result for the rule of law, showing the expected negative and statistically significant effect, implies that countries with a strengthened rule of law curb underground participation (Models 2.3-2.4). The results with respect to the other controls closely support the baseline models (Models 2.1-2.2).

4.3. Accounting for the potential impact of outliers

It is possible that some nations might have abnormally high/low rates of epidemic diffusion or of the shadow economy. These large variations in the spread of epidemics are also evident in the current case of COVID-19 (https://coronavirus.jhu.edu/map.html). Accordingly, as a robustness check, we account for the possible influence of outliers employing robust regressions.

[7] We also checked the robustness of these findings by considering additional covariates including a measure of regulatory quality, population density, and exports as a percentage of GDP. These results, not reported here but available upon request, continue to support our baseline models.

In particular, robust regression corrects for outliers by utilizing Cook's distance less than one and conducts Huber iterations and then biweight iterations (see Li (1985)).

We re-estimate the baseline equations using robust regression and present the results in Models 3.1-3.2 of Table 3. The results continue to show that the coefficients on *EpidemINC* and *EpidemDIFF* are positive and statistically significant at the 1% level, thus supporting the baseline findings that the presence and intensity of epidemics are positively associated with the shadow economy. The results for the control variables are in line with our earlier findings.

4.4. Accounting for the potential simultaneity between epidemics and the shadow economy

It is possible that there are reverse feedbacks from the shadow economy to epidemics – for instance, nations with a large shadow economy (since the informal sector operators do not follow health and safety regulations and are not monitored), might have a larger incidence and diffusion of epidemics.

To mitigate concerns with endogeneity, we, therefore, employ the lagged values of *EpidemINC* and *EpidemDIFF* and re-estimate the baseline specifications. The results, displayed in Models 3.3 and 3.4 of Table 3, show that the coefficients on lagged values of *EpidemINC* and *EpidemDIFF* are positive and statistically significant at conventional levels, thereby confirming our baseline results. This also suggests that the impact of epidemics on the shadow economy persists over time, which is in line with the reasoning of Jordá et al. (2020). The results for the remainder of the variables are consistent with our baseline findings.

4.5. Accounting for the potential simultaneity between growth and the shadow economy

Economic growth is an overarching measure with potentially numerous linkages. Thus, a useful test of the validity of our findings should address the possible simultaneity between economic growth and the shadow economy that might bias our results. A large shadow economy might promote growth and development by, for example, providing complementary goods and services (e.g. sub-contracting) or it might deter growth by undermining the government's ability to collect tax revenues that are used to finance growth-supporting public goods (see Schneider and Enste (2000) and Goel et al. (2019) for a discussion). Furthermore, most of the other control variables could have a relation with economic growth.

To alleviate issues with reverse causality between economic growth and the shadow economy, we re-estimate the baseline models without the control variable *ECgrowth* and present the corresponding results in Models 3.5 and 3.6 of Table 3.[8] The coefficients on *EpidemINC* and *EpidemDIFF* remain positive and statistically significant, thereby instilling confidence in our baseline findings – again, as hypothesized, epidemics feed the informal sector. As before, the control variables show similar influences on the shadow economy.

4.6. Accounting for country-specific characteristics

As our next robustness check, we account for unique country-specific characteristics that may impact the relationship between epidemics and the shadow economy. For example, cultural differences that are mostly fixed over our time of study likely influence the spread of epidemics and the size of the shadow economy. To check the robustness of our main results to country-specific heterogeneity, we re-estimate the baseline models controlling for country-fixed effects.

[8] As an additional robustness check, we also considered the lagged value of *ECgrowth* in the baseline models. Re-estimating the baseline models with the lagged value of *ECgrowth* confirmed our main findings – these results are available upon request.

These results are reported as Models 3.7 and 3.8 in Table 3. The coefficients on *EpidemINC* and *EpidemDIFF* retain their sign and significance, albeit slightly smaller in magnitude relative to the baseline models. Furthermore, the control variables maintain their sign and significance with the important exception that government size is no longer statistically significant. Thus, while the variable government size is no longer significant when country-specific characteristics are accounted for, our main hypothesis is still supported.

4.7. Accounting for heterogeneous effects related to income and geography

In spite of the different controls that we employ to capture cross-country variations, it is possible that some of the structural and institutional differences cannot be readily quantified. As a result, we consider different samples of nations to shed additional light on the results – see Table 1A for each sub-sample of countries. To this end, we split the sample of countries into non-OECD and OECD countries. Additionally, we account for the unique geography of non-island relative to island nations. Island nations have natural barriers against the spread of epidemics from other nations, and they are also somewhat insulated from shadow economy spillovers from neighboring nations (Goel and Saunoris (2014); Berdiev and Saunoris (2020)). On the other hand, the OECD group of nations is quite prosperous and has strengthened institutions which might help fight epidemics and control the shadow economy as well. In our overall sample of 129 nations, there were 109 non-island nations and 31 OECD nations.

The results, replicating the baseline models from Table 2, are presented in Table 4. We find that the emergence and severity of an epidemic is positively associated with the size of the shadow economy in non-island (Models 4.1 and 4.2). This suggests that non-island nations are similar to the overall sample – there remains the positive influence of epidemics on the prevalence of the shadow economy, and this is true both for the incidence and the diffusion of epidemics. On the other hand, non-island nations, Models 4.3-4.4, did not see any appreciable impact on the shadow economy from epidemics. This could be because there is relatively better monitoring of informal activities, fewer informal sector opportunities, or a lack of spillovers from immediate neighbors in such nations.

The impacts of epidemics are again similar for the non-OECD group (Models 4.5 and 4.6). However, we find interesting differences for the OECD nations – both the incidence and intensity of epidemics have no appreciable impact on the shadow economy in OECD nations (Models 4.7 and 4.8). This is likely due to strengthened institutions and greater opportunity costs of operating in the illegal shadow sector in these nations. Further, the wealthier nations are able to provide relatively more generous fiscal support to the general public in times of epidemics/crisis. Therefore, while in the current COVID-19 crisis, the wealthier nations seem to be no less impacted than other nations in terms of the health impacts, they may be somewhat better insulated in terms of the spillovers on the shadow or the underground sector.

Overall, in terms of spillovers on the shadow economy from epidemics, the OECD nations and island nations are similar, while the group of non-OECD nations is similar to the non-island group. This has some implications for cross-national policy coordination.

The results from the robustness checks largely confirm the validity of our baseline findings that the occurrence of epidemics and the severity of epidemics drive entrepreneurs underground. The concluding section follows.

5. Conclusions

The current coronavirus crisis has added a sense of urgency to related effective health and economic policies (https://www.cdc.gov/coronavirus/2019-ncov/index.html; https://www.weforum.org/covid-action-platform). The scale and scope of the unexpected events have challenged resources and policymakers. Academics are also trying to respond to this challenge by providing new insights, although all related data for many analyses will only emerge over time.

Whereas numerous drivers of the shadow economy have been considered in the literature (Gërxhani (2004); Goel and Nelson (2016); Schneider and Enste (2000)), the consideration of spillovers from epidemics is new. The informal sector undermines compliance with government regulations and lowers tax collections. Our main hypothesis is that epidemics positively impact the spread of the shadow economy, and we consider both the incidence of epidemics and their intensity (in terms of afflictions).

Using panel data on nearly 130 nations and nesting the empirical analysis in the broader literature on the drivers of the shadow sector, we find that both the incidence and the intensity of epidemics positively and significantly contribute to the spread of the underground sector. Numerically, a ten percent increase in the intensity of epidemics leads to an increase in the prevalence of the shadow economy by about 2.1 percent. These main findings withstand alternative considerations of possible simultaneity, outliers, subsamples of nations, and different sets of controls. The other results regarding the influence of economic and political freedoms largely support the literature.

These findings about the spillovers from epidemics have implications for economic policies in the current times, contributing to the renewed academic interest in the economics epidemics (Baldwin and di Mauro (2020), Folgi and Veldkamp (2019), Rasul (2020)). In particular, in the present COVID-19 era, while government efforts are primarily directed towards containment and treatment of the virus, it would behoove policymakers to pay some attention to spillovers on economic activities, such as the shadow economy. One specific policy implication might be that island nations and OECD could have similar policies for containment of the informal sector following epidemics. Such attention to the informal sector is important because a greater shadow economy limits government resources which would undermine the fight for future diseases, and the containment of current ones due to lax adherence with health and safety regulations.

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Table 1: Variable definitions, data sources, and summary statistics

Variable	Description [observations; mean; standard deviation]	Source
Shadow	The size of the shadow economy as a percent of GDP measured using the multiple indicators, multiple causes (MIMIC) method. [3950; 32.28; 12.52]	Medina and Schneider (2017)
EpidemINC	Dummy variable equal to 1 for the country and year in which there was an epidemic between 1991-2015, and zero otherwise. Epidemics caused by infectious diseases that are categorized as viral, bacterial, fungal or prion. [5919; 0.14; 0.35]	Emergency Events Database#
EpidemDIFF	The log of one plus the total number affected each year between 1991-2015 (i.e. 100 or more people that are affected, injured or homeless as a result of the epidemic) by the pandemic divided by population (in millions). [5788; 0.56; 1.77]	Emergency Events Database#
ECgrowth	Economic growth measured as the log difference of per capital real GDP per capita. [4917; 1.88; 6.11]	The World Bank (2018)
PolFreedom	Index of political freedom measured as the sum of civil liberties and political rights. This index is based on a scale from 2 to 14, with higher numbers denoting more political freedom. [4962; 6.83; 3.98]	Freedom House
BureauQual	Index bureaucratic quality, measuring the strength and quality of bureaucracy on 0-4 scale, with higher numbers denoting a higher quality. [3391; 2.19; 1.14]	The PRS Group
GovtSize	Government size, measured as government final consumption expenditures as a percent of GDP. [4307; 20.87; 9.10]	The World Bank (2018)
EconFreedom	Index of economic freedom on a scale from 0 to 100, with higher numbers denoting more freedom. [3533; 59.22; 11.84]	Heritage Foundation (2017)
RuleLaw	Index of the rule of law on a scale from -2.5 to 2.5, with higher numbers denoting stronger rule of law. This is a perceptions based index capturing the text to which people abide by the rules of society, quality of contract enforcement, property rights, police, courts and the likelihood of crime. [3752; 0.00; 1.00]	Kaufmann et al. (2016)
UNEMP	Unemployment rate (%). [4810; 8.69; 6.38]	The World Bank (2018)
EDUC	Primary school enrollment as a percent of gross enrollment. [4062; 100.28; 17.12]	The World Bank (2018)

Notes: Summary statistics based on all available data from 1991 to 2015. # Emergency Events Database (EM-DAT) from the Centre for Research on the Epidemiology of Disasters (CRED, www.cred.be).

Table 2: Epidemics and the shadow economy: Baseline and extended models
Dependent variable: *Shadow*

	Baseline models		**Robustness check R1: Alternate control variables**					
	(2.1)	(2.2)	(2.3)	(2.4)	(2.5)	(2.6)	(2.7)	(2.8)
EpidemINC	1.320**		1.048*		1.334**		1.100*	
	(0.545)		(0.581)		(0.545)		(0.611)	
EpidemDIFF		0.275***		0.247**		0.278***		0.252**
		(0.104)		(0.115)		(0.104)		(0.116)
ECgrowth	-0.142***	-0.131***	-0.137***	-0.125**	-0.142***	-0.131***	-0.116**	-0.103*
	(0.049)	(0.049)	(0.053)	(0.054)	(0.049)	(0.050)	(0.053)	(0.054)
PolFreedom	0.450***	0.433***	0.085	0.071	0.456***	0.440***	0.434***	0.421***
	(0.080)	(0.081)	(0.103)	(0.105)	(0.081)	(0.082)	(0.092)	(0.094)
BureauQual	-3.504***	-3.641***	-1.967***	-2.126***	-3.495***	-3.630***	-3.814***	-3.965***
	(0.278)	(0.283)	(0.330)	(0.336)	(0.278)	(0.284)	(0.305)	(0.311)
GovtSize	-0.202***	-0.208***	-0.130***	-0.130***	-0.205***	-0.210***	-0.257***	-0.266***
	(0.027)	(0.028)	(0.031)	(0.032)	(0.027)	(0.027)	(0.031)	(0.031)
EconFreedom	-0.169***	-0.167***	-0.005	-0.006	-0.167***	-0.166***	-0.092***	-0.087***
	(0.026)	(0.026)	(0.035)	(0.036)	(0.026)	(0.026)	(0.030)	(0.030)
RuleLaw			-4.756***	-4.668***				
			(0.561)	(0.571)				
UNEMP					0.021	0.021		
					(0.031)	(0.032)		
EDUC							-0.015	-0.013
							(0.012)	(0.013)
<u>Elasticity</u>								
EpidemDIFF		0.207***		0.177**		0.210***		0.177**
		(0.078)		(0.082)		(0.078)		(0.082)
Observations	2,492	2,430	2,057	2,004	2,492	2,430	2,168	2,113
Number of countries	129	129	129	129	129	129	128	128
R-squared	0.560	0.563	0.580	0.583	0.560	0.563	0.538	0.542

Notes: See Table 1 for variable details. Regional fixed-effects and a constant are included in each model, but not reported. Robust standard errors are in parentheses. Asterisks denote the following significance levels: *** p<0.01, ** p<0.05, and * p<0.1.

Table 3: Epidemics and the shadow economy: Robustness checks
Dependent variable: *Shadow*

Robustness checks →	**R2: Robust Regression**		**R3: Simultaneity**		**R4: No Growth**		**R5: Country heterogeneity**	
	(3.1)	(3.2)	(3.3)	(3.4)	(3.5)	(3.6)	(3.7)	(3.8)
EpidemINC	1.157**				1.381**		0.808***	
	(0.456)				(0.546)		(0.244)	
EpidemDIFF		0.297***				0.293***		0.102**
		(0.090)				(0.103)		(0.046)
$EpidemINC_{t-1}$			0.945*					
			(0.546)					
$EpidemDIFF_{t-1}$				0.203**				
				(0.102)				
ECgrowth	-0.092**	-0.080*	-0.145***	-0.149***			-0.111***	-0.109***
	(0.041)	(0.041)	(0.048)	(0.048)			(0.024)	(0.024)
PolFreedom	0.476***	0.459***	0.449***	0.426***	0.456***	0.438***	0.406**	0.390*
	(0.071)	(0.071)	(0.080)	(0.081)	(0.080)	(0.081)	(0.201)	(0.202)
BureauQual	-2.930***	-3.028***	-3.512***	-3.662***	-3.434***	-3.578***	-1.540***	-1.525***
	(0.248)	(0.251)	(0.278)	(0.284)	(0.277)	(0.283)	(0.582)	(0.571)
GovtSize	-0.251***	-0.258***	-0.204***	-0.212***	-0.202***	-0.207***	0.053	0.043
	(0.024)	(0.024)	(0.027)	(0.028)	(0.028)	(0.028)	(0.062)	(0.063)
EconFreedom	-0.210***	-0.206***	-0.170***	-0.170***	-0.164***	-0.163***	-0.229***	-0.232***
	(0.022)	(0.022)	(0.026)	(0.026)	(0.026)	(0.026)	(0.066)	(0.066)
Observations	2,492	2,430	2,492	2,431	2,492	2,430	2,492	2,430
Number of countries	129	129	129	129	129	129	129	129
R-squared	0.574	0.579	0.559	0.562	0.558	0.562	0.119	0.115

Notes: See Table 1 for variable details. Models 3.1-3.6 include regional fixed-effects, and Models 3.7-3.8 account for country fixed-effects. Robust standard errors are in parentheses. Asterisks denote the following significance levels: *** $p<0.01$, ** $p<0.05$, and * $p<0.1$.

Table 4: Epidemics and the shadow economy: Considering different groups of nations
Dependent variable: *Shadow*

Sample ⟶	**Non-Island**		**Island**		**Non-OECD**		**OECD**	
	(4.1)	(4.2)	(4.3)	(4.4)	(4.5)	(4.6)	(4.7)	(4.8)
EpidemINC	1.493**		0.914		1.651***		1.157	
	(0.590)		(1.189)		(0.580)		(0.706)	
EpidemDIFF		0.279**		0.172		0.291***		0.321
		(0.111)		(0.225)		(0.105)		(0.204)
ECgrowth	-0.126**	-0.118**	-0.323***	-0.299***	-0.205***	-0.190***	-0.046	-0.054
	(0.053)	(0.053)	(0.095)	(0.098)	(0.056)	(0.057)	(0.059)	(0.059)
PolFreedom	0.648***	0.629***	0.374**	0.377**	0.421***	0.409***	2.243***	2.220***
	(0.089)	(0.090)	(0.158)	(0.162)	(0.087)	(0.088)	(0.524)	(0.524)
BureauQual	-3.477***	-3.632***	0.295	0.223	-2.363***	-2.535***	-5.797***	-5.761***
	(0.292)	(0.297)	(0.881)	(0.915)	(0.317)	(0.325)	(0.475)	(0.478)
GovtSize	-0.206***	-0.211***	-0.067	-0.076	-0.198***	-0.207***	0.177***	0.170***
	(0.028)	(0.029)	(0.097)	(0.099)	(0.029)	(0.030)	(0.039)	(0.039)
EconFreedom	-0.126***	-0.124***	-0.632***	-0.629***	-0.131***	-0.129***	-0.242***	-0.243***
	(0.030)	(0.030)	(0.058)	(0.060)	(0.030)	(0.030)	(0.038)	(0.038)
Observations	2,117	2,066	375	364	1,859	1,798	633	632
Number of countries	109	109	20	20	98	98	31	31
R-squared	0.545	0.548	0.758	0.759	0.381	0.383	0.585	0.584

Notes: See Table 1 for variable details. Regional fixed-effects and a constant are included in each model, but not reported. Robust standard errors are in parentheses. Asterisks denote the following significance levels: *** p<0.01, ** p<0.05, and * p<0.1.

APPENDIX
Table 1A: Countries used in the analysis

Albania	Ecuador	Lebanon	Russian Federation
Algeria	Egypt, Arab Rep.	Liberia	Saudi Arabia
Angola	El Salvador	Libya	Senegal
Argentina	Estonia*	Lithuania	Sierra Leone
Armenia	Finland*	Luxembourg*	Singapore^
Australia*	France*	Madagascar^	Slovak Republic*
Austria*	Gabon	Malawi	Slovenia*
Azerbaijan	Gambia, The	Malaysia	South Africa
Bahamas, The^	Germany*	Mali	Spain*
Bahrain^	Ghana	Malta^	Sri Lanka^
Bangladesh	Greece*	Mexico	Suriname
Belarus	Guatemala	Moldova	Sweden*
Belgium*	Guinea	Mongolia	Switzerland*
Bolivia	Guinea-Bissau	Morocco	Tanzania
Botswana	Guyana	Mozambique	Thailand
Brazil	Haiti^	Myanmar	Togo
Brunei Darussalam^	Honduras	Namibia	Trinidad and Tobago^
Bulgaria	Hungary*	Netherlands*	Tunisia
Burkina Faso	Iceland*^	New Zealand*^	Turkey
Cameroon	India	Nicaragua	Uganda
Canada*	Indonesia^	Niger	Ukraine
Chile	Iran, Islamic Rep.	Nigeria	United Arab Emirates
China	Ireland*^	Norway*	United Kingdom*^
Colombia	Israel*	Oman	United States*
Congo, Dem. Rep.	Italy*	Pakistan	Uruguay
Congo, Rep.	Jamaica^	Papua New Guinea^	Venezuela, RB
Costa Rica	Japan*^	Paraguay	Vietnam
Cote d'Ivoire	Jordan	Peru	Yemen, Rep.
Croatia	Kazakhstan	Philippines^	Zambia
Cyprus^	Kenya	Poland*	Zimbabwe
Czech Republic*	Korea, Rep.*	Portugal*	
Denmark*	Kuwait	Qatar	
Dominican Republic^	Latvia	Romania	

Notes: N = 129. * denotes OECD countries (31) and ^ denotes island countries (20).