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Dirty Money: Does the Risk of Infectious Disease Lower Demand for Cash?

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Abstract

The coronavirus pandemic is a global crisis like no other in modern times, and there is a growing apprehension about handling potentially contaminated cash. This paper is the first empirical attempt in the literature to investigate whether the risk of infectious diseases affects demand for physical cash. Since the intensity of cash use may influence the spread of infectious diseases, this paper utilizes two-stage least squares (2SLS) methodology with instrumental variable (IV) to address omitted variable bias and account for potential endogeneity. The analysis indicates that the spread of infectious diseases lowers demand for physical cash, after controlling for macroeconomic, financial, and technological factors. While the transactional constraints imposed by the COVID-19 pandemic could become a catalyst for the use of digital technologies around the world, electronic payment methods may not be universally available in every country owing to financial and technological bottlenecks.

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I. INTRODUCTION

The coronavirus pandemic is a global crisis like no other in modern times— an unprecedented international public health concern causing a deep and broad economic recession. As of November 19, 2020, there are over 56.4 million confirmed cases of the COVID-19 in 190 countries, with more than 1.3 million deaths.[2] According to the World Health Organization (WHO), with no specific vaccines or treatments for SARS-CoV-2, the coronavirus responsible for the COVID-19 pandemic, the best way to prevent and slow down spread of the virus is through mitigation and containment measures, including travel restrictions, business and school closings, and social distancing in general.

There is a growing apprehension about handling cash, and some central banks have taken preventive steps, including sanitizing banknotes, to lower the risk of disease transmission. While some studies show that the fibrous surfaces of banknotes can become contaminated with disease-causing bacteria and viruses (Pope and others, 2002; Thomas and others, 2008; Vriesekoop and others, 2010; Angelakis and others, 2014; Chin and others, 2020), others argue that handling cash is not necessarily a greater source of health risk (Panetta, 2020; van Doremalen and others, 2020). Preliminary data present conflicting signals: physical cash held by the public appears to have increased in some countries during the early days of the COVID-19 pandemic (Chen and others, 2020; Goodhart and Ashworth, 2020), while there is a decline in the withdrawal volume from automated teller machines (ATMs) and a significant increase in the use of mobile applications for financial transactions in most countries (Auer, Cornelli, and Frost, 2020; Carvalho and others, 2020; Fu and Mishra, 2020). Therefore, it is an empirical question whether the risk of infectious diseases with human-to-human transmission can cause a precautionary decline in demand for physical cash and give boost to alternative means of payments, including not only debit and credit cards but new payments methods such as mobile payments and central bank digital currency, a digital version of cash.

The widespread use of electronic payment methods is already common in many countries, driven by demographic characteristics, innovations in payment technology, and evolving consumption patterns (Humphrey, Pulley, and Vesala, 1996; Stavins, 2001; Stix, 2004; Amromin and Chakravorti, 2007; Borzekowski, Kiser, and Shaista, 2008; Ching and Hayashi, 2010; Schuh and Stavins, 2010; Arango, Huynh, and Sabetti, 2011; von Kalckreuth, Schmidt, and Stix, 2014; Bagnall and others, 2016; Bech, Shimizu, and Wong, 2017; Adrian and Mancini-Griffoli, 2019; Khiaonarong and Humphrey, 2019). Even so, demand for cash remains strong, with currency-in-circulation increasing from a global average of 6.2 percent in 1995 to 8.8 percent in 2017. This trend is particularly pronounced in international currencies like the U.S. dollar and the euro, due partly to international demand. Cash is also found to become more attractive during large economic shocks, like the global financial crisis with low or negative interest rates that reduced

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[2] The latest figures can be found at John Hopkins University's Center for Systems Science and Engineering: https://www.arcgis.com/apps/opsdashboard/index.html#/bda7594740fd40299423467b48e9ecf6.

the opportunity cost of holding cash in a period of heightened economic uncertainty and led to an increase in currency-in-circulation (Jobst and Stix, 2017; Ashworth and Goodhart, 2020).

There is no research looking at the impact of public-health concerns on demand for cash in the economy. Infectious-disease outbreaks could either lead to a hoarding of cash by consumers and businesses for precautionary reasons or reduced cash use through payment behavior changes giving boost to alternative means of payments, including mobile applications. The objective of this paper is therefore to fill this gap in the literature to the extent possible by investigating whether the prevalence of infectious diseases affects cash demand in a panel of 133 countries over the period 1995–2017. It would be ideal to use the breakdown of cash and non-cash transactions in the economy to better identify the impact of pandemics, but this information is available for only a small number of large countries during a recent time period.[3] Accordingly, this paper uses comparable data on currency-in-circulation to estimate the intensity of cash use across a large set of countries and utilizes the two-stage least squares (2SLS) methodology with instrumental variables (IV) to address omitted variable bias and account for potential endogeneity. The empirical analysis indicates that the spread of infectious diseases with human-to-human transmission lowers demand for physical cash, after controlling for macroeconomic, financial, and technological factors. This effect, withstanding several robustness checks, is economically and statistically significant. For example, a one percentage-point increase in the number of confirmed infectious-disease cases scaled by population is associated with a decline of 1.68 percent in currency-in-circulation as a share of GDP.

Infectious diseases like COVID-19 may spread through respiratory droplets that can land on items people touch and spread the infection further. According to van Doremalen and others (2020), this does not necessarily mean that banknotes and coins present a greater health risk than other types of surfaces, including credit cards and mobile phones, which may provide better surfaces for infected droplets, depending on temperature and humidity, than the more porous surface of banknotes.[4] Electronic payment methods, however, are not universally available in every country due to financial and technological bottlenecks, which limit access to finance. Further, cash is also a store of value—an important attribute that gains prominence in times of greater economic uncertainty. In particular, when banks appear to be vulnerable, as was the case in many countries during the global financial crisis, cash may be considered a superior store of value than other financial instruments.

While behavioral changes during an infectious-disease outbreak should not be extrapolated into permanent effects, the COVID-19 pandemic—spreading to 190 countries across the world with

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[3] The Bank for International Settlements (BIS) publishes statistics on payments and financial market infrastructures in 25 countries for the period 2014-2018: https://www.bis.org/statistics/payment_stats.htm.

[4] The ECB, for example, finds no evidence of the coronavirus having been spread via banknotes (Panetta, 2020). It should also be noted that a growing number of countries already use polymer banknotes which are unlikely to act as a transmitter for viruses or bacteria. However, the costs involved with the large-scale printing and redistribution of new banknotes—or sterilization of existing banknotes—are substantial, and might dissuade many central banks from taking these steps, especially in developing and low-income countries.

devastating socioeconomic consequences—will likely have a greater effect on cash demand than past epidemics. The transactional constraints imposed by the pandemic already appears to have become a catalyst accelerating the shift toward electronic payment methods, including central bank digital currency. These emerging instruments function not only as a method of payment, but also as a platform through which governments can achieve greater efficiency and effectiveness in disbursing cash transfers, especially during natural disasters and economic crises (Agur, Martinez Peria, and Rochon, 2020; Auer and others, 2020; Una and others, 2020). The challenge for policymakers is to ensure financial inclusion, especially in countries where financial and technological bottlenecks impede the availability of electronic payment methods, and address the vulnerability of digital financial services to cyberattacks, digital fraud, and money-laundering attempts.

The remainder of this study is organized as follows. Section II provides an overview of the data used in the empirical analysis. Section III introduces the empirical strategy and presents the empirical results, including a series of robustness checks. Section IV offers concluding remarks with policy implications.

II. STYLISED FACTS AND DATA OVERVIEW

The COVID-19 pandemic is an unparalleled shock, with the global spread of a highly contagious disease forcing countries to shut down economic activity. The number of confirmed COVID-19 cases reached over 56.4 million and caused more than 1.3 million deaths in 190 countries around the world. Other infectious diseases with human-to-human transition do not have the geographical reach of COVID-19, with the exception of the Spanish Flu of 1918 which is estimated to have a global death toll of nearly 50 million. The unprecedented scale of the COVID-19 outbreak is not only a risk to human life and a cause of economic angst, but also a source of significant psychological and behavioral changes that alter consumption and investment patterns (Andersen and others, 2020; Baker and others, 2020; Balkhi and others, 2020; Coibion, Gorodnichenko, and Weber, 2020; Dubey and others, 2020; Sheth, 2020; Wagner, 2020; Zhang, Hu, and Ji, 2020).

Although there is no unambiguous evidence on the transmission of COVID-19 (or other infectious diseases) through banknotes and coins, the perception of risks associated with the use of cash is enough for precautionary adjustments in behavior.[5] Some central banks have introduced measures to sterilize paper money, while the U.S. Federal Reserve has begun quarantining dollar banknotes returning the country for at least a week (Schroeder and Irrera, 2020). Nevertheless, preliminary data show an increase in currency-in-circulation in the first quarter of 2020 in some countries, including the U.S. and the Euro zone. On the other hand, there is a significant decline in the volume of ATM withdrawals, along with a surge in credit and debit card transactions (Carvalho and others, 2020). Similarly, Fu and Mishra (2020) find an increase in

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[5] The WHO has not advised banning banknotes and coins, but it has stressed the need for handwashing after touching cash, especially before handling food.

the use of mobile applications for financial transactions during the COVID-19 era in a sample of 74 countries.

The empirical analysis presented in this study is based on an unbalanced panel of annual observations for 133 countries during the period 1995–2017. Since it is not straightforward to separate the foreign component of demand for reserve currencies, Euro-area countries, Switzerland, the United Kingdom, and the United States are excluded from the sample. The dependent variable is demand for cash in the economy as approximated by currency-in-circulation as a share of GDP, which is frequently used in the literature (Amromin and Chakravorti, 2007; Khiaonarong and Humphrey, 2019). There are arguably better measures of cash use throughout the economy, such as the difference between the value of household consumption and the value of all non-cash payment instruments used in consumption or the value of all cash withdrawals from the banking sector as a ratio to cash plus the value of payment instruments that substitute for cash, as suggested by Khiaonarong and Humphrey (2019). However, data limitations prevent calculating such series in most countries. As a result, this paper uses comparable data on currency-in-circulation, obtained from the IMF's International Financial Statistics (IFS) database, to estimate the intensity of cash use.

The main explanatory variable of interest is the number of confirmed cases of infectious disease with human-to-human transmission, including Ebola and SARS, which are obtained from the WHO database and scaled by population. As a robustness check, health spending as a share of GDP is used as an instrumental variable for infectious diseases. Following the literature, real GDP per capita in local currency, a novel measure of informality in economic activity, the average interest rate on bank deposits, financial development as measured by domestic credit to the private sector as a share of GDP, and mobile phone penetration as the number of subscribers per 1,000 are introduced as control variables, drawn from the World Bank's World Development Indicators (WDI) database. The informality measure used in the analysis is estimated by Medina and Schneider (2019) with the multiple indicator-multiple cause (MIMIC) approach. The definition and measurement of the informal economy remains an empirical challenge, with a variety of direct and indirect methods of estimation proposed in the literature. The MIMIC model explicitly considers causes and indicators of the informal economy and treats it as an unobserved component. One important criticism of the MIMIC approach, however, is the use of GDP per capita and growth of GDP per capita as cause and indicator of the size of the informal economy. Medina and Schneider (2019) address this issue by using the night light intensity measured by satellites as alternative measure of the size of the economy.

Descriptive statistics for the variables used in the empirical analysis are presented in Table 1. There is a significant degree of dispersion in terms of currency-in-circulation across countries and over time and considerable heterogeneity in the occurrence of infectious diseases as well as in the level and evolution of control variables.[6] It is essential to analyze the time-series properties of the data to avoid spurious results by conducting panel unit root tests. The stationarity of all

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[6] The sample used in this paper has 2,806 observations for infectious diseases, 1,505 out of which are non-zero.

variables is checked by applying the Im-Pesaran-Shin (2003) procedure, which is widely used in the empirical literature to conduct a panel unit root test. The results, available upon request, indicate that the variables used in the analysis are stationary after logarithmic transformation.

Table 1. Summary Statistics

Variables	Obs.	Mean	Std. Dev.	Min.	Max.
Currency-in-circulation	3,428	8.9	31.9	1.0	856.0
Real GDP per capita	3,473	13,155	16,243	184	111,968
Informality	3,082	32.8	12.0	9.2	70.5
Deposit interest rate	2,269	8.7	9.5	0.0	147.1
Financial development	3,417	40.4	37.7	0.4	309.0
Mobile phone penetration	3,394	54.4	50.6	9.5	251.8
Health spending	2,166	5.7	2.2	1.1	20.4
Infectious diseases					
Ebola	3,542	25	527	0.0	14,124
SARS	3,542	2	94	0.0	5,327

Source: IMF; World Bank; WHO; author's calculations.

III. EMPIRICAL METHODOLOGY AND ESTIMATION RESULTS

Building on the recent literature (Stix, 2004; Bech and others, 2018; El Hamiani Khatat, 2018), this study augments the model for demand for cash with infectious diseases as the main explanatory variable of interest and estimates the following specification:

$$Cash_{it} = \beta + \alpha\, Vir_{it} + \gamma\, X_{it} + \eta_i + \mu_t + \varepsilon_{it}$$

where $Cash_{it}$ denotes currency-in circulation as a share of GDP in country i at time t; Vir_{it} is the number of confirmed cases of infectious diseases with human-to-human transmission (Ebola and SARS) scaled by population; and X_{it} represents a vector of control variables, including real GDP per capita, a measure of informality in economic activity, deposit interest rates, financial development, and mobile phone penetration. The η_i and μ_t coefficients denote the country-specific fixed effects capturing time-invariant unobservables and the time fixed effects controlling for common shocks that may affect demand for cash across all countries in a given year, respectively. ε_{it} is an idiosyncratic error term that satisfies the standard assumptions of zero mean and constant variance, with robust standard errors clustered at the country level to account for possible heteroskedasticity.

The objective of this paper is to empirically investigate the impact of infectious diseases on demand for cash. Since some studies indicate that the prevalence of cash use may also influence the spread of infectious diseases (Pope and others, 2002; Vriesekoop and others, 2010; Angelakis and others, 2014), it is necessary to address omitted variable bias and account for potential endogeneity (or reverse causality) in an econometric analysis of this nature. The challenge is to find a robust time-varying IV, which needs to be correlated with infectious diseases, but have no

contemporaneous effect on currency-in-circulation. Accordingly, this paper uses the 2SLS-IV approach and instruments the contemporaneous measure of infectious disease with its own lags and alternatively with health spending as a share of GDP. Table 2 presents the 2SLS-IV estimation results, with the number of confirmed cases of infectious disease scaled by population is introduced into the regression one by one: Ebola in column (1), SARS in column (2), and all infectious diseases, including Ebola, malaria, SARS and yellow fever, in column (3).

Table 2. Infectious Diseases and Demand for Cash—Baseline Estimations

(Dependent variable: Currency-in-circulation/GDP)			
	[1]	[2]	[3]
Real GDP	-5.943***	-4.399***	-6.915***
	[3.540]	[3.656]	[3.744]
Informality	0.547**	0.473**	0.414**
	[0.243]	[0.338]	[0.258]
Deposit interest rate	-0.028	-0.012	-0.013
	[0.083]	[0.089]	[0.088]
Financial development	-0.012**	-0.009**	-0.010**
	[0.053]	[0.056]	[0.059]
Mobile phone penetration	-0.080**	-0.056**	-0.048**
	[0.031]	[0.036]	[0.034]
Ebola	-1.630***		
	[1.380]		
SARS		-1.439**	
		[1.365]	
All infectious diseases			-1.682***
			[1.861]
Number of countries	133	133	133
Number of observations	1,880	1,880	1,880
Country FE	Yes	Yes	Yes
Time FE	Yes	Yes	Yes
F-stat	52.4	54.0	52.5
[p-value]	0.00	0.00	0.00
Adjusted R^2	0.77	0.78	0.80

Note: The dependent variable is currency-in-circulation as a share of GDP. Robust standard errors are reported in brackets. A constant is included in each regression, but not shown in the table. *, **, and *** denote significance at the 10%, 5%, and 1% levels, respectively.

The results demonstrate a consistent picture with the signs of all estimated parameters corresponding to their expected values across different specifications. Currency-in-circulation as a share of GDP is inversely related to the level of income, suggesting that demand for cash tends to be lower, on average, in more developed economies. This is also consistent with the positive effect of the informality variable, which indicates that cash use is higher in countries with a large shadow economy. Deposit interest rates—denoting the opportunity cost of holding cash—have a negative coefficient, but do not appear to be a statistically significant effect on currency-in-circulation. Financial development, on the other hand, is found to have a negative association with demand for physical cash in the economy, as expected. In a similar vein, mobile phone penetration appears to lower currency-in-circulation in the economy by enabling financial inclusion and access to alternative forms of payment. These variables also help control for differences in financial inclusion and physical infrastructure, which may influence demand for cash throughout the economy. Overall, estimated elasticities for the conventional determinants of cash demand are consistent with previous studies in the literature.

With regards to the main variable of interest in this study, the number of confirmed cases of infectious disease scaled by population is found to have a statically significant negative effect on demand for cash in the economy. The coefficient on infectious diseases ranges between -1.439 for SARS, -1.630 for Ebola and -1.682 for all infectious diseases, always remaining negative and statistically significant. In the case of Ebola, for example, a one percentage point increase in the number of confirmed cases is associated with a decline of 1.63 percent in currency-in-circulation as a share of GDP. Although statistically less significant, a one percentage point increase in the number of confirmed SARS cases is still found to contribute to a decline of 1.44 percent in demand for cash in the economy. The magnitude and statistical significance of the coefficient on all infectious diseases, including Ebola, malaria, SARS and yellow fever, is even greater at -1.68. These results suggest that the higher the risk of infectious disease, the lower the intensity of cash use on average, after controlling for macroeconomic, financial, and technological factors.

A series of robustness checks are conducted to validate the baseline results.[7] First, the sample is truncated at the 5th and 95th percentiles to remove the potential impact of outliers. Second, the model is estimated for a sub-sample of 1995-2007 to exclude the period after the global financial crisis. Third, the model is estimated for a sample of 105 developing and low-income countries. Fourth, the model is estimated with health spending as an alternative IV for infectious diseases. Finally, the model is estimated without the informality measure, which may cause an endogeneity problem due to the use of monetary variables in its construction. These results, presented in Table 3, show that the negative and economically significant relationship between demand for cash and the number of confirmed cases of infectious disease remains in line with the baseline findings, with some changes in the magnitude of estimated coefficients. Furthermore, partitioning the sample into country groups reveals that the magnitude and statistical significance of the impact of infectious diseases are much greater in developing and

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[7] To exhibit a concise table, the robustness checks are presented only for Ebola, but the estimation results remain consistent for SARS.

low-income countries, where such diseases tend to be more prevalent. Finally, using health spending as an alternative instrument for infectious diseases confirms the significant negative impact of infectious diseases on demand for physical cash.

Table 3. Infectious Diseases and Demand for Cash—Robustness Checks

	Tructacted sample	Sub-sample (1995-2007)	Developing & low-income	Alternative IV (health spending)	Excluding informality
	(Dependent variable: Currency-in-circulation/GDP)				
Real GDP	-1.478***	-15.19***	-7.916***	-6.092***	-7.931***
	[0.262]	[2.994]	[3.744]	[3.165]	[3.147]
Informality	0.110***	0.145***	0.415**	0.509**	
	[0.017]	[0.135]	[0.258]	[0.296]	
Deposit interest rate	-0.012	-0.044	-0.013	-0.029	-0.007
	[0.007]	[0.051]	[0.009]	[0.085]	[0.082]
Financial development	-0.011**	-0.006**	-0.049**	-0.028**	-0.040**
	[0.004]	[0.015]	[0.059]	[0.056]	[0.052]
Mobile phone penetration	-0.004**	-0.097**	-0.019**	-0.046**	-0.013**
	[0.002]	[0.035]	[0.034]	[0.087]	[0.029]
All infectious diseases	-0.150***	-0.242**	-1.158***	-1.852***	-1.155***
	[0.085]	[0.135]	[0.268]	[1.110]	[0.243]
Number of countries	126	128	105	130	133
Number of observations	1,661	919	1,840	1,521	2,069
Country FE	Yes	Yes	Yes	Yes	Yes
Time FE	Yes	Yes	Yes	Yes	Yes
F-stat	78.9	31.3	46.9	41.7	48.0
[*p*-value]	0.00	0.00	0.00	0.00	0.00
Adjusted R^2	0.86	0.79	0.77	0.77	0.77

Note: The dependent variable is currency-in-circulation as a share of GDP. Robust standard errors are reported in brackets. A constant is included in each regression, but not shown in the table. *, **, and *** denote significance at the 10%, 5%, and 1% levels, respectively.

IV. CONCLUSION

The COVID-19 pandemic is a global crisis like no other in modern times—an unprecedented international public-health concern causing a deep economic recession with far-reaching financial implications. As infectious diseases like COVID-19 may spread through respiratory droplets that can land on items people touch, there has long been a debate over risks associated with handling physical cash with conflicting evidence on whether the fibrous surfaces of banknotes can become contaminated with disease-causing bacteria and viruses. While this does not necessarily indicate that banknotes and coins present a greater health risk than other types of surfaces, recent studies show that the coronavirus can remain infectious on surfaces such as banknotes, phone screens and stainless steel for 28 days (Chin and others, 2020; van Doremalen and others, 2020). That is why it is an empirical question whether an increase in the risk of

infectious diseases with human-to-human transmission causes a precautionary fall in demand for physical cash and gives boost to alternative means of payments.

This paper is the first empirical attempt in the literature to investigate whether the risk of infectious diseases affects the intensity of cash use. Since the prevalence of cash use may influence the spread of infectious diseases, the 2SLS-IV methodology is utilized to address omitted variable bias and account for potential endogeneity. The empirical results indicate that an increase in the number of confirmed cases of infectious disease with human-to-human transmission (such as Ebola and SARS) lowers demand for physical cash in the economy, after controlling for macroeconomic, financial and technological factors. This effect, withstanding several robustness checks, is economically and statistically significant. For example, a one percentage point increase in the number of confirmed infectious-disease cases is associated with a decline of 1.68 percent in currency-in-circulation as a share of GDP. Looking forward, the COVID-19 outbreak—the first truly global pandemic in modern times spreading to 190 countries with devastating consequences—can also be expected to have a greater effect on currency-in-circulation as a share of GDP over the long term.

The empirical findings presented in this paper, however, are not a call to abolish cash altogether—or at all. Electronic payment methods may not be universally available in every country due to financial infrastructure and technological bottlenecks, which limit access to finance. Further, cash is also used as a store of value, which becomes an important attribute in times of greater economic uncertainty. Especially when banks appear to be vulnerable, as was the case in many countries during the global financial crisis, cash gains more prominence as a store of value than other financial instruments. Nevertheless, the transactional constraints imposed by the COVID-19 pandemic have already become a catalyst for speeding up the shift toward digital forms of money, including central bank digital currency, across the world. First, there has been a significant increase in online shopping, where cash is simply not a payment option. Second, both businesses and consumers appear to have preferred digital forms of payment to minimize the use of cash in store transactions. As a result, preliminary data indicate a decline in ATM withdrawals and a significant increase in the use of mobile applications for financial transactions.

Policymakers should not treat digital transformation of financial services as a binary process, especially in countries where financial and technological bottlenecks impede the availability of electronic payment methods. These structural changes could certainly bring significant benefits in terms of faster speed in processing transactions and greater variety, efficiency and convenience in financial services as well as in in disbursing cash transfers, especially during natural disasters and economic crises. But it is also important to acknowledge potential costs associated with post-pandemic digital transformation that could lead to greater cross-border spillovers, undermine financial stability, and complicate the conduct of macroeconomic policy. In particular, digital forms of money and other financial services are more vulnerable to cyberattacks and fraud, especially in developing countries where digital infrastructure is lagging behind, and require strengthening know-your-customer procedures and anti-money laundering compliance.

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