Received: 17 April 2022 | Revised: 22 December 2022 | Accepted: 9 January 2023

DOI: 10.1111/twec.13390

ORIGINAL ARTICLE

The World Economy WILEY

Epidemic outbreak and foreign direct investment fluctuation

Zhen Yu[1] | **Yuankun Li**[2] | **Jing Zhao**[3,4]

[1]Institute for the U.S. and Canadian Economies, Wuhan University, Wuhan, China

[2]PBC School of Finance, Tsinghua University, Beijing, China

[3]Faculty of Business, City University of Macau, Taipa, Macao SAR, China

[4]Hong Kong Institute of Asia-Pacific Studies, The Chinese University of Hong Kong, Shatin, Hong Kong

Correspondence
Jing Zhao, Faculty of Business, City University of Macau, Luso-Chinese Building 4F, Avenida Padre Tomás Pereira, Taipa, Macao SAR, China.
Email: jingzhao750@126.com

Funding information
National Office for Philosophy and Social Sciences, Grant/Award Numbers: 16ZDA039, 20VYJ035; Ministry of Education of the People's Republic of China, Grant/Award Number: 2020-N45

Abstract
This paper studies how foreign direct investment (FDI) inflows will fluctuate when the host country is hit by an epidemic outbreak. By analysing historical outbreak and bilateral FDI data from 2001 to 2012, we find FDI inflows during an outbreak are 21.5% below the pre-outbreak average and 21.6% above the pre-outbreak average FDI inflows in the 3 years after the end of an outbreak, which highlights the compensatory FDI after the end of epidemic and implies the uncertainty mechanism. We confirm the validity of the uncertainty mechanism, which converts the health shock into risk factors in the real economy, by studying the industry-level heterogeneity and showing that the M&A in industries with lower redeployability is more sensitive to epidemic outbreaks. Finally, we explore country-level heterogeneity that may influence the relationship between epidemic outbreaks and FDI inflows. We find that countries with poor medical conditions suffer greater decreases in FDI inflows during outbreaks, and countries with poorer institutional quality do not experience compensatory FDI after an outbreak ends.

KEYWORDS
epidemic outbreak, foreign direct investment, FDI dynamics, uncertainty

1 | INTRODUCTION

Covid-19, which continues to spread globally, has an impact on many international economic activities. Although such a large global epidemic outbreak bringing extremely negative economic outcomes is rare in history, regional epidemic outbreaks are more frequent than we thought.[1] A growing literature has studied the economic consequences following a health shock. In particular, infectious diseases have more negative externalities and can cause greater social panic than non-communicable diseases (Bish & Michie, 2010; Bloom et al., 1998, 2014, 2019; Bloom & Mahal, 1997; Hassan et al., 2020; Yu et al., 2021). Despite the relatively clear conclusion that the epidemic will hurt the economy in the short run, how the economy will recover remains unclear. Moreover, limited attention has been given to foreign direct investments (FDIs). This paper studies the influence of epidemics on FDI inflows in both the short-run and long-run by highlighting the role of uncertainty in creating the fluctuation of FDI.

As an important source of capital, FDI has become increasingly important for economic development after decades of economic globalisation. Moreover, FDI fluctuations can affect the stability of economies and even cause financial crises, balance of payment problems, debt defaults, inflation periods and currency crashes (Reinhart & Reinhart, 2008). In addition to the typical determining factors studied in previous literature (Aisbett, 2017; Frenkel & Walter, 2019; Li, 2010; Li et al., 2018), FDI seems extremely sensitive to epidemic outbreaks. For example, after the recent outbreak of Covid-19, global foreign direct investment (FDI) collapsed in 2020, falling 42% from $1.5 trillion in 2019 to an estimated $859 billion,[2] which was even 30% lower than that during the 2008–2009 global financial crisis. Some studies identified epidemic outbreaks' negative effects on FDI inflows in the short run (Fu et al., 2021; Oh et al., 2020). Our baseline findings using historical data from 2002 to 2012 also find that FDI inflows decrease by 21.5% during the outbreak period. Even though the negative economic impacts of the epidemic on FDI inflow seem indisputable, the recovery pattern after the epidemic is still ambiguous and is becoming a major concern in the industry, academia and government. Furthermore, our recent experience with Covid-19 also tells us that the impact of the epidemic on the economy and subsequent recovery patterns could be heterogeneous across countries, which is also worthy of deep investigation.

To identify the causal relationship between epidemic outbreaks and FDI and to investigate the fluctuation pattern following epidemic outbreaks, we employ a difference-in-differences (DID) strategy to take advantage of the variation in both time and country dimensions. An epidemic outbreak in certain locations and certain time points is believed to be random (Yu et al., 2021), which provides a natural experiment setting for identifying and causal effect of an epidemic outbreak on FDI. Specifically, we embed our DID approach in a gravity model, which can analyse both unilateral and bilateral factors influencing the FDI flow. Moreover, we create shock dummies not only for the epidemic years but also for the following 3 years after the end of outbreaks to explore both the short-run and long-run effects of the epidemic on FDI (Cui et al., 2019; Parker et al., 2016). Finally, we adopt the continuous DID setting by using the affected number and the number of deaths to measure the intensity of the outbreak to investigate the magnitude of the relationship between the severity of the epidemic and FDI flow.

We find that the negative effects of epidemic outbreaks are temporary. Moreover, we find that the epidemic outbreaks, on average, will not reduce the FDI inflows from a relatively long-run perspective but mainly delay them. In other words, the FDI inflows will fluctuate in an S-shape, featured with the initial drop and later overshooting. Specifically, despite the initial sharp drop (21.5%), there will be an overshooting of FDI, which is even 21.6% higher than the average level of FDI in the pre-shock

[1]According to the Emergency Events Database (EM-DAT), there were only 39 outbreaks of large-scale infectious diseases between 1950 and 1980, but between 1980 and 2010, there were 346 outbreaks in 85 countries, a nearly nine-fold increase.
[2]Global FDI data is obtained from the United Nations Conference on Trade and Development (UNCTAD) Investment Trends Monitor.

periods. Moreover, the more deaths or infections during the epidemic outbreak periods, the more volatile the FDI inflows will be. Based on these baseline findings, from the policy-making perspective, the government should make efforts to stabilise FDI flows and take methods to prevent further crises related to FDI fluctuation.

Our baseline findings of the S-shaped fluctuation and overshooting of FDI further imply the validity of the uncertainty mechanism. In addition to the traditional FDI-determining factors, like market size and economic growth, theories and empirical evidence have been developed to emphasise the role of uncertainty in making investment decisions. Uncertainty makes investors wait for more information and thus often delays irreversible investments (Bernanke, 1983; Dixit, 1989; Julio & Yook, 2016; Kim & Kung, 2017). Foreign investors may be more concerned about uncertainty since they are faced with an unfamiliar market environment and even additional regulations and treatment. To explore the mechanism of uncertainty, we use industry-level variation in the redeployability of assets, which is negatively correlated with the irreversibility of investments.[3] We find that mergers and acquisitions in industries requiring more irreversible investments are more sensitive to epidemic outbreaks in the host countries, suggesting that the epidemic outbreaks in host countries cause FDI inflows to fluctuate by introducing uncertainty to the economy. The mechanism study suggests policies should be targeted to reduce uncertainty and help firms that invest in industries requiring irreversible assets.

To investigate the heterogeneity across the countries and determine what country characteristics will help mitigate the influence of epidemic outbreaks, we take advantage of country-level variation in medical-care conditions and institutional quality. The existing literature finds that bad healthcare conditions can amplify the adverse effects of disease outbreaks (Baldwin & di Mauro, 2020; McKibbin & Fernando, 2021) and increase the uncertainty about the severity and duration of the epidemic. Additionally, institutional quality has been identified as a critical factor in attracting FDI by increasing return, reducing cost, and reducing uncertainty (Bénassy-Quéré et al., 2007; Daude & Stein, 2007; Julio & Yook, 2016; Wei, 2000).

This paper uses the number of hospital beds per capita as a proxy for healthcare conditions and the regulation quality index from the World Bank's World Governance Indicators (WGI) database. We then interact these country characteristics with the epidemic dummies to explore possible heterogeneous effects. We find that the decline in FDI in countries with poor medical conditions during the epidemic was significantly greater than in countries with good medical conditions. In other words, bad medical conditions will magnify the initial adverse impact of epidemic outbreaks and lead to create more volatility. In terms of regulation, although there is no significant difference in the initial FDI reduction, we find that countries with poorer institutional quality will not experience compensatory FDI increases after the epidemic outbreaks end, which means these countries will lose investments during the epidemic outbreak. These findings on the heterogeneity effects suggest that improving the healthcare system and government regulation would help to stabilise the FDI flows by mitigating the negative impact of the epidemic outbreaks and promoting better recovery.

In addition to policy implications, this paper contributes to the literature in three ways. First, we supplement the literature about factors causing FDI fluctuation, like sudden drop, rebound or overshooting. Identifying the various causes and patterns of FDI fluctuation is crucial not only because FDI stability relates to the stability of the macroeconomy but also because appropriate intervention policies should be developed based on specific causes. Supply-side, demand-side, or uncertainty shocks should be handled with different measures.[4] Our results show that epidemic outbreaks will cause FDI inflows to fluctuate in an S shape and highlight the important underlying mechanism of

[3]Kim and Kung (2017) find a strong relationship between asset redeployability and investment sensitivity to uncertainty.

[4]Forbes and Warnock (2012) suggest different policies should be adopted for domestic and global causes respectively.

uncertainty, which is discussed by investment theories emphasising the value of waiting for more information. Theories predict that due to the irreversibility of investments, firms will temporarily stop investments when uncertainty increases and resume them once the uncertainty is resolved. Despite the large literature confirming the drop of investments or FDI when uncertainty is high, only a few studies on the rebound or overshooting of investments after the shock (except Julio & Yook, 2016). Our findings of the overshooting of investments, as well as the larger effect of epidemic outbreaks on industries with higher irreversibility, jointly provide evidence to the theories explaining the relationship between uncertainty and investment dynamics.

Second, we contribute to the literature on how country characteristics, such as medical conditions and institutional quality, affect FDI. In particular, we explore how epidemic outbreaks provides a channel through which institutional quality and medical condition take effect. Many studies have identified a host country's bad institutional quality in various aspects, including political risk, poor government transparency, corruption, unpredictability of laws, regulations and policies, excessive regulatory burden, government instability, weak protection of property rights and legal inefficiency, etc., directly deter cross-border capital flows (Alfaro et al., 2008; Daude & Stein, 2007; Gelos & Wei 2005; Papaioannou, 2009; Wei, 2000). However, institutional quality can influence FDI decisions through the uncertainty channel as well. Julio and Yook (2016) and Khoury and Peng (2011) show that better institution quality may alleviate the negative effect of political uncertainty on FDI. During the special time of epidemic outbreaks and their aftermath, we also identified the unique role of institutional quality. Poor institutional quality hinders the recovery and is likely to reduce inward FDI for a relatively long period. Besides, we find that medical condition becomes a critical factor in business decisions when a health shock hits the economy since countries with poorer will suffer from a larger decrease in FDI during epidemics. Our findings make a unique contribution by showing unconventional economic variables may become the unique determinant of FDI when a special channel or window is opened.

Finally, we contribute to the recent literature investigating how epidemic outbreaks affect economic outcomes. Scholars found that epidemic outbreaks can lead to various economic and social problems, such as long-term regional poverty (Ambrus et al., 2020), reduction of human capital investment (Fortson, 2011), reduction of saving (Baranov & Kohler, 2018), lack of trust (Aassve et al., 2020), increased violence (Gonzalez-Torres & Esposito, 2020), breeding prejudice (Jedwab et al., 2019), declining capital profit margins and slowing economic growth (Bloom & Mahal, 1997; Karlsson et al., 2014; McDonald & Roberts, 2006). In our study, we focus on FDI and highlight the uncertainty mechanism, which contributes to this strain of literature and has important social and economic policy implications.

The structure of this paper is arranged as follows. The second section reviews the literature and develops our hypotheses. The third section explains the data and the construction of the key variables. The fourth section articulates the identification strategy. The fifth section presents and analyzes the empirical results, while the last section concludes.

2 | LITERATURE REVIEW AND HYPOTHESIS DEVELOPMENT

2.1 | Economic shocks and uncertainty brought by epidemic outbreaks

Epidemic outbreaks may affect the real economy by bringing shocks in demand, supply chain, finance and uncertainty (Altig et al., 2020; Baldwin & di Mauro, 2020; Eichenbaum et al., 2021; Hassan et al., 2020; Yu et al., 2020), which further reduce investments, output, productivity and economic growth (Bloom et al., 1998, 2019; Bloom & Mahal, 1997). Besides the demand and supply shocks, which directly affect investment or FDI, the uncertainty shock affects firms' investment uniquely. Compared to domestic investments, foreign investments could be even more very sensitive to uncertainty.

Epidemic outbreaks create uncertainty in many aspects, including the spread and duration of the disease (Fauci et al., 2020), the persistence and intensity of intervention policies, the economic policies to deal with the economic downturn and boost recovery (Baker et al., 2016), as well as the economic prospects in the future (Al-Thaqeb et al., 2020; Altig et al., 2020; Bloom et al., 2014, 2019; Clark et al., 2015; Dew-Becker & Giglio, 2020). Besides these discussions about how uncertainty is injected by the epidemic outbreaks, more evidence has been provided by researchers trying to quantify the level of uncertainty. Using stock market volatility measures and newspaper-based measures of economic uncertainty, Altig et al. (2020) find the uncertainty brought by the recent Covid-19 pandemic exceeds the one in the 2009 Great Recession and is close to uncertainty in the 1930s Great Depression. Besides, previous regional epidemic outbreaks like SARS and H1N1 also caused the uncertainty indices to increase (Ahir et al., 2018; Altig et al., 2020).

2.2 | Uncertainty and investment fluctuation

Faced with increased uncertainty during the epidemic outbreak, firms are likely to change their investment time (Altig et al., 2020; Fu et al., 2021; Gujrati & Uygun, 2020). Analogous to the real options theory in the financial market, which emphasises that the real value of waiting rises with increased uncertainty, theories linking uncertainty and investment have been developed. Under the assumption that an investment project is at least partially irreversible and that new information about returns is arriving over time, uncertainty raises the value of waiting and also the upper investment threshold (Bernanke, 1983; Chi et al., 2019; Lee & Makhija, 2009). Hence, faced with increasing uncertainty, some of the investments will be suspended. However, these suspended investments are not very likely to be cancelled (Baker et al., 2016; Gulen & Ion, 2016; Julio & Yook, 2012), considering that foreign investors primarily focused on long-term economic and institutional factors in host countries (Nielsen et al., 2017), which are rarely affected by temporary shocks (Acemoglu & Johnson, 2007, 2014; Dahl et al., 2020). After the uncertainty is resolved, firms will resume these suspended plans and make compensatory investments. When these compensatory investments are summed up with the originally planned investments in normal periods, there will be an overshooting of investment at the aggregated level (Bloom, 2009; Rivoli & Salorio, 1996; Rodrik, 1991; Stokey, 2016).[5] These theories not only provide a new perspective to explain investment decisions but also allow for a richer dynamic framework than the traditional theory of investment.

Besides the theories developed, many empirical studies identified the role of uncertainty in investment dynamics. They find that policy uncertainty reduces corporate investment (Baker et al., 2016; Gulen & Ion, 2016; Kim & Kung, 2017), R&D investment (Bhattacharya et al., 2017) and merger and acquisition (Bonaime et al., 2018; Nguyen & Phan, 2017). In particular, some scholars focused on FDI and used the exogenous political event to study the effect of uncertainty on FDI (Azzimonti, 2019; Julio & Yook, 2016). They find that despite the decrease in FDI during the uncertain period, FDI rebounds with a vengeance once uncertainty resolves.

[5]An outbreak will generate exogenous uncertainty in both time and magnitude, which alters the entry time of MNCs (Al-Thaqeb et al., 2020; Hitt et al., 2021; Sharma et al., 2020).

2.3 | The hypothesis developed based on theories about uncertainty and investment

Based on the theories explaining how uncertainty affects investments and the fact that epidemic outbreak generates a high level of uncertainty, we propose Hypothesis 1:

Hypothesis 1a. The effect of an outbreak on FDI is temporal: that is, during the outbreak, FDI inflows decrease significantly compared to the pre-outbreak period, and after the end of the outbreak, FDI inflows recover.
Hypothesis 1b. The overall negative effect of an outbreak on FDI is quite limited.

Hypotheses 1a and 1b predict that epidemic outbreaks create fluctuation of FDI inflows but will not reduce the overall amount of inward FDI in the relatively long term. Therefore, investigating Hypothesis 1 not only helps to uncover the effect of epidemic outbreaks on FDI but also provides indirect evidence on the underlying mechanism of uncertainty since uncertainty shocks are likely to create overshooting of FDI and are unlikely to cause cancellation of investments.

Besides, we may examine the uncertainty mechanism by taking advantage of the variation in sensitivity or vulnerability to uncertainty. According to the theories discussed above, the critical characteristic, which makes investments sensitive to uncertainty, is their irreversibility. Studies have uncovered that the irreversibility of investment is strongly industry-specific (Bonaime et al., 2018; Julio & Yook, 2016; Kim & Kung, 2017). Particularly, Kim and Kung (2017) constructed industry-level redeployability indices based on an industry's liquidity in the secondary market. The high level of redeployability indicates that the assets are easier to liquidity and the associated investments are easier to be reversed, which makes the industries less responsive to uncertainty. If the epidemic outbreak affected FDI through an uncertainty mechanism, industries with a higher redeployability index should be less affected by the epidemic. Therefore, to test the uncertainty mechanism, we propose Hypothesis 2:

Hypothesis 2. Inward FDI in Industries with higher redeployability drop less when an epidemic outbreak hits the host country.

In addition to the causal relationship between epidemic outbreaks and FDI, we also explore country-specific factors influencing this relationship to support relevant policy-making. Previous studies show that two country-specific characteristics, medical or healthcare system and institutional quality, may affect how epidemic outbreaks influence FDI inflow.

Medical-care conditions in the host country are the basic guarantee of life, thereby the basic guarantee of smoothy progress of economic activities. In normal periods, the healthcare system may have a limited effect on FDI. However, when disasters occur, such as epidemic outbreaks, it becomes a critical factor in business decisions. Hence, a high level of the healthcare system in the host country can mitigate direct influence as well as the uncertainty caused by an epidemic outbreak (Sawchuk, 2020; Yu et al., 2020).

As discussed in Section 1, existing literature finds that institutional quality is not only a direct determinant factor of FDI but also influences FDI indirectly through the uncertainty channel. At the particular time of the outbreak, on the one hand, good regulatory quality and efficient policy-making play an important role in containing the expansion of the outbreak (Yu et al., 2021), while the countries with poorer institutional quality may suffer more from epidemic outbreaks in the sense of more infection, more mortality, longer duration and more complications or sequelae such as disorder, civil unrest and increased violence (Finley & Koyama, 2018; Gonzalez-Torres & Esposito, 2020; Jedwab et al., 2019). In this way, the country with poorer institutional quality may experience more economic loss during the epidemic and weaker recovery after the epidemic. On the other hand, institutional quality also interacts with uncertainty to influence FDI. Julio and Yook (2016) find better institutional quality reduces FDI fluctuation when political uncertainty increases in countries. In other words, better institutional quality mitigates the potential influence of uncertainty.

To explore the host country characteristics that can influence the relationship between FDI and epidemic outbreak, we propose Hypotheses 3a and 3b:

Hypothesis 3a. Countries with poorer public health care suffer greater declines in FDI during an outbreak or/and experience worse recovery.

Hypothesis 3b. Countries with poorer institutional quality suffer greater declines in FDI during an outbreak or/and experience worse recovery.

3 | DATA DESCRIPTION AND VARIABLE CONSTRUCTION

This study combines data about bilateral FDI, epidemic outbreaks, unilateral country characteristics and country-pair bilateral controls. After cleaning and merging the data sets from different sources, we come up with a panel ranging from 2000 to 2012 with 42,589 observations. The definition and sources of the variables are listed in Table 1. Table 2 demonstrates the summary statistics of all variables.

3.1 | Bilateral FDI data

Bilateral FDI flow data come from the bilateral FDI statistics database of the United Nations Conference on Trade and Development (UNCTAD), which produces annual reports documenting bilateral FDI flows from 2001 to 2012. The data report the total value of bilateral FDI flows of both M&As and greenfield investments in which share purchases exceed 10% of total shares by year. The sample includes 99,504 pairs of bilateral investment flows involving 203 host economies and 215 home economies.[6]

3.2 | Epidemic outbreak data

The epidemic outbreak data come from the Emergency Events Database (EM-DAT), which includes more than 15,700 global cases since 1900. As a disaster database at the global level, EM-DAT has become the core database in many research fields, including disaster economics.

As part of the natural disaster data in the EM-DAT database, Epidemic outbreak data come from the World Health Organization and the national centres for disease control in different countries. It includes the outbreaks when the death number is above nine, or the infection number is no less than 99. It reveals the start date, end date, country of outbreaks, virus type, event name, number of infections, deaths and other relevant information.

In our study, we clean the data in several ways. First, following Gassebner et al. (2006), we only select the outbreaks that cause more than 100 death so that they may have a relatively significant influence on the economy.[7] Second, to match the annually reported FDI data, we use the starting year

[6]This data set has been used in many research focusing on FDI. In particular, Chen and Lin (2020) have verified the credibility of this data set in detail.

[7]The number of deaths was selected as the screening standard because the number of deaths and the number of infected * mortality, which takes into account the infectivity (number of infected) and severity (case fatality rate) of the disease. In the existing literature on the classification of infectious diseases, it is considered more scientific to classify the infectiousness and lethality of a disease (Qualls et al., 2017).

TABLE 1 Definition of variable.

Variable	Definition	Source
$FValues_{ijt}$	Bilateral FDI inflow value transformed by IHS	UNCTAD
$Shock\_Period_{jt}$	Dummy variable for whether country *j* is in an infectious disease outbreak in year t	EM-DAT
$Deaths\_Period_{jt}$	Logarithmic number of deaths caused by the outbreak if country *j* is in the treatment group and is experienced an epidemic outbreak in year *t*, otherwise will be 0.	EM-DAT
$Affected\_Period_{jt}$	Logarithmic number of affected caused by the outbreak if country *j* is in the treatment group and is experienced an epidemic outbreak in year *t*, otherwise will be 0.	EM-DAT
$Shock\_After_{jt}$	Dummy variable for whether country *j* is in the treatment group and year *t* is within 3 years after the end of the epidemic	EM-DAT
$Deaths\_After_{jt}$	Logarithmic number of deaths caused by the outbreak if country *j* is in the treatment group and year *t* is within 3 years after the end of the epidemic, otherwise, we make it 0.	EM-DAT
$Affected\_After_{jt}$	Logarithmic number of affected caused by the outbreak if country *j* is in the treatment group and year *t* is within 3 years after the end of the epidemic, otherwise, we make it 0.	EM-DAT
$\text{Ln}GDPcap_{jt}$	GDP per capita	CEPII
$Openness_{jt}$	(Export + Import)/GDP	World Bank WDI database
$GovExp_{jt}$	Government expenditure to GDP ratio	World Bank WDI database
GDP_Growth_{jt}	GDP growth rate	World Bank WDI database
$\text{Ln}ExRate_{jt}$	Change of the exchange rate (Logarithmic form)	Penn table (9.1 version)
$Rent_{jt}$	Resource rent	World Bank WDI database
$Deflator_{jt}$	GDP deflator	World Bank WDI database
$Patent_{jt}$	Patent holding	World Bank WDI database
FTA_{ijt}	Free Trade Agreement	WTO
BIT_{ijt}	Bilateral investment treaty	UNCTAD
$Disaster_{jt}$	Whether other natural disasters occur	EM-DAT
War_{ijt}	Whether there is a war in the host country	Correlates of War (COW) database
$Regulation_{jt}$	Regulation quality, a measure of Institutional Quality	World Bank WGI database
PoorRegulation	Indicator for poor regulation quality (lower than the median)	World Bank WGI database

Note: This table provides definitions and sources of the variables.

and ending year to identify the timing of epidemic outbreaks, even though the epidemic outbreak is recorded on a daily basis. In particular, if a country has multiple outbreaks in the same year, we select only the one that causes the most casualty during that year.[8] If one outbreak lasts more than 1 year, we treat all the years as epidemic outbreak years. In fact, only four infectious disease outbreaks in our sample span over 1 year, while the rest all ended within a single year since the epidemiological

[8]This is because data for small outbreaks are often missing.

TABLE 2 Summary statistics.

Variable	Mean	SD	Min	Max	*N*
$FValues_{ijt}$	1.551	3.496	−11.689	12.368	42,589
$Shock\_Period_{jt}$	0.019	0.137	0.000	1.000	42,589
$Deaths\_Period_{jt}$	0.107	0.768	0.000	8.841	42,589
$Affected\_Period_{jt}$	0.172	1.254	0.000	13.163	42,589
$Shock\_After_{jt}$	0.043	0.202	0.000	1.000	42,589
$Deaths\_After_{jt}$	0.239	1.138	0.000	7.448	42,589
$Affected\_After_{jt}$	0.379	1.826	0.000	12.000	42,589
$\mathrm{Ln}GDPcap_{jt}$	9.155	1.409	5.472	11.642	42,589
$Openness_{jt}$	91.857	62.152	20.686	437.327	42,589
$GovExp_{jt}$	16.817	4.736	5.023	33.413	42,589
$GDPGrowth_{jt}$	3.489	4.159	−14.814	34.466	42,589
$\mathrm{Ln}ExRate_{jt}$	−0.009	0.096	−0.332	1.120	42,589
$Rent_{jt}$	4.147	7.511	0.000	52.157	42,589
$Deflator_{jt}$	5.446	6.125	−18.899	75.277	42,589
$Patent_{jt}$	10.447	36.030	0.001	274.033	42,589
FTA_{jt}	0.345	0.475	0.000	1.000	42,589
BIT_{ijt}	0.097	0.295	0.000	1.000	42,589
$Disaster_{jt}$	0.2445	0.4298	0.0000	1.0000	42,589
War_{ijt}	0.0030	0.0550	0.0000	1.0000	42,589
$Regulation_{jt}$	63.4909	26.9169	0.4695	100.0000	42,589

Note: This table reports descriptive statistics for all variables. Matching FDI inflow data with other control variables, we obtain 42,589 sample items, covering 101 host economies and 161 home economies. Following Frenkel and Walter (2019), we apply inverse hyperbolic sine (IHS) transformation to the value of FDI inflows to avoid outliers that may affect our results.

definition of infectious disease outbreak emphasises that several patients with the same infectious disease should suddenly appear in a local area 'within a short period of time'. Finally, we focus on the epidemic outbreaks from 2000 to 2012 due to the limit of the FDI data, which is only available for this period.

Given the above selection criteria, we include 101 epidemic outbreaks in our sample. Figures 1 and 2 show the time and geographic distribution of global infectious disease outbreaks.

3.3 | Other control variables

Based on the vast literature study on the determinant factors of FDI inflows (Azzimonti, 2019; Chan & Zheng, 2017; Julio & Yook, 2016; Poelhekke & van der Ploeg, 2013), we control a comprehensive set of typical host economy characteristics and bilateral variables that may affect the FDI flows in the gravity equation. The typical host country's unilateral variables include income level (GDP per capita, denoted by Ln*GDPcap*), GDP growth rate (*GDP_Growth*), natural resource rent (denoted as *Rent*) and patent holding (*Patent*). These host country variables capture the market, resource-seeking and innovation-seeking motives of FDI (Huang & Wang, 2013). International trade is also closely related

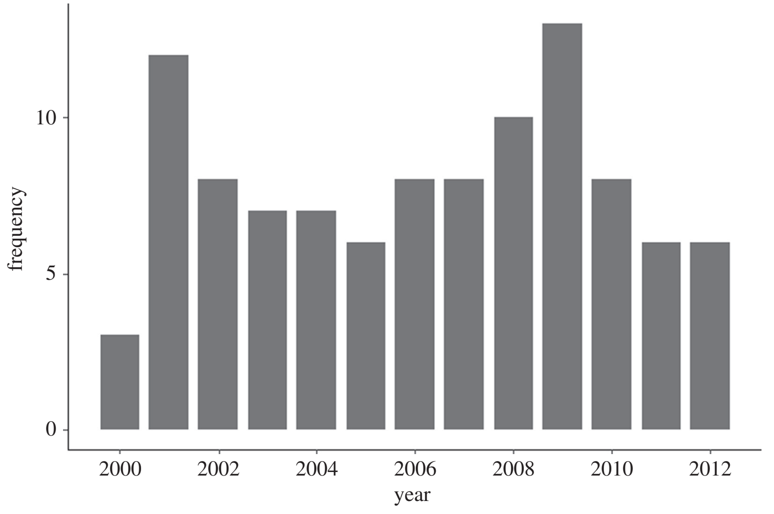

FIGURE 1 The frequency of global infectious disease outbreaks (2001–2012). *Note*: This figure shows the frequency of global infectious disease outbreaks by year. The data source for epidemic outbreaks is EM-DAT.

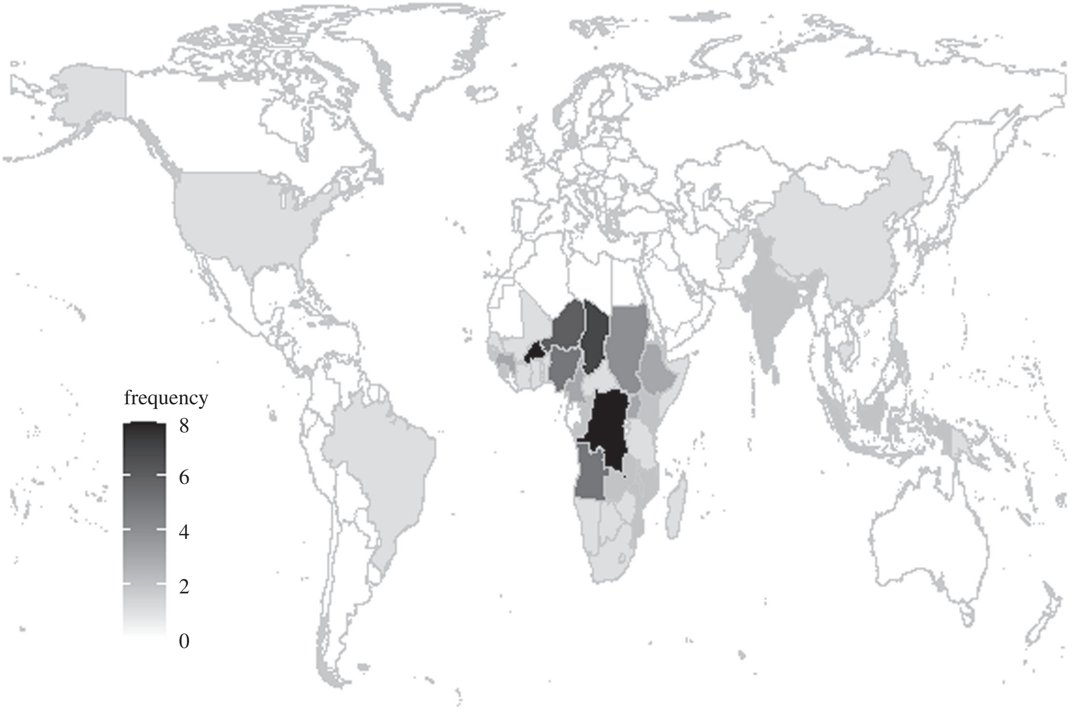

FIGURE 2 Geographic distribution of global infectious disease outbreaks (2001–2012). *Note*: This figure shows the spatial distribution of global infectious disease outbreaks. The data source of epidemic outbreaks is obtained from EM-DAT.

to FDI,[9] hence we include the degree of openness (*Openness*) in our model, which is defined as total exports and imports divided by GDP (Blonigen & Piger, 2014). The government expenditure scaled down by GDP (denoted by *GovExp*) is also included to represent the state capacity of host countries. Finally, the growth of exchange rate (denoted by Ln*ExRate*) and GDP deflator (denoted by *Deflator*) is included to deal with the price factors which may influence the purchasing power of investors.

In addition, typical bilateral controls like free trade agreements (denoted by *FTA* and retrieved from World Trade Organization) and bilateral investment treaties (denoted by *BIT* and obtained from United Nations Conference on Trade and Development) are also included. Besides the typical variables in the gravity equation, we include institutional quality, particularly the regulation quality of host countries (denoted by *Regulation*) as suggested by the literature discussed in Sections 1 and 2. The measure of institutional quality is obtained from the World Governance Indicators (WGI) database of the World Bank.[10] Finally, we include dummy variables for other natural disasters (denoted by *Disaster*) and wars (denoted by *War*) to further alleviate the omitted variable bias since these confounding factors may cause epidemic outbreaks and influence the economic outcomes at the same time.[11] The natural disaster data come from the EM-DAT database. The war data come from the COW (Correlates of War) database.[12]

4 | EMPIRICAL STRATEGY

As discussed in Sections 1 and 2, epidemic outbreaks inject uncertainty into the economy, which may further influence investment behaviour in both the short and long run. In this part, we develop the baseline empirical models to study the short-run, long-run and overall effects. In particular, we design models to test Hypothesis 1 proposed in Section 2.3.

Following the literature on international trade and the determinants of FDI, we embed the DID method in a simple gravity model for bilateral FDI flows. The previous data summary tells us that epidemic outbreaks hit different countries in different years. Moreover, for a country, the outbreak of an epidemic at a certain time can be thought of as random (Yu et al., 2021) or exogenous to other economic factors determining FDI. Therefore, we may treat the epidemic outbreak as a natural experiment and compare the change of FDI inflow between countries hit by epidemic outbreaks with others to investigate the causal relationship between epidemic outbreaks and FDI. In other words, our empirical strategy fits in a staggered difference-in-differences setting. Moreover, by defining different time dummies, we design different econometric models to study the short-run, long-run and overall effects of epidemic outbreaks on inward FDI.

4.1 | Short-run and long-run effects of epidemic outbreaks on FDI inflows

We start with Hypothesis 1a, which explores the short-run and long-run effects of outbreaks. In particular, we are interested in how FDI inflows will fluctuate when the host country is hit by an outbreak. Especially, will there be a recovery or even overshooting in FDI in the long run?

[9]More detailed discussions about how FDI and international trade are related could be found in Lipsey and Weiss (1984) and Markusen (1995).

[10]More detailed introduction about this data set and measure is in Section 5.4.2.

[11]Many outbreaks of infectious diseases are caused by other natural disasters. For example, cholera may be caused by floods, and malaria may be caused by drought. In addition, war makes a country chaotic and increases the probability of infectious disease outbreaks. Following the same rules as infectious disease outbreaks, we only included natural disasters that caused more than 100 deaths.

[12]Data source: https://correlatesofwar.org/data-sets/COW-war.

We followed previous literature (Cui et al., 2019; Parker et al., 2016) and created dummies for both the epidemic year (treatment year) and the following 3 years after the epidemic outbreak ends (post-treatment). By doing so, we can compare the treatment and post-treatment periods (3 years after the treatment) with the normal periods, which include years before the epidemic outbreak and years long after the end of the epidemic outbreak.[13] The corresponding econometric models are illustrated in Equation (1):

$$FValues_{ijt} = \beta_1 Shock\_Period_{jt} + \beta_2 Shock_{After_{jt}} + \beta'_X \boldsymbol{x}_{jt} + \beta'_Z \boldsymbol{z}_{ijt} + \boldsymbol{\gamma}_{ij} + \boldsymbol{d}_{it} + \varepsilon_{ijt}, \tag{1}$$

where the dependent variable, $FValues_{ijt}$, is the inverse hyperbolic sine (IHS) transformation of bilateral FDI flows from country i to country j at year t.[14] The key independent variable is $Shock\_Period_{jt}$ the dummy variable capturing the year of the epidemic outbreak in host country j, and $Shock\_After_{jt}$, the dummy variable capturing the 3 years after the end of an epidemic outbreak. Specifically, we assign $Shock\_After_{jt}$ a value of 1 if country j has experienced epidemic outbreaks in years $t-3$, $t-2$ or $t-1$; otherwise, we assign it a value of 0. Hence, the dummy capturing the outbreaking years ($Shock\_Period_{jt}$) helps to identify the short-run effect, while the dummy representing the years after the end of the outbreak ($Shock\_After_{jt}$) helps to explain the influence in the relatively long run. A negative β_1 and a positive β_2 may indicate that the FDI fluctuates in an S-shape, which is featured with the overshooting of FDI, and that the uncertainty mechanism is likely to take effect.

The vector x_{jt} represents a series of unilateral control variables of host country characteristics, including GDP per capita, degree of openness, Government expenditure to GDP ratio, GDP growth rate, exchange rate, Natural Resource rent, GDP deflator, Patent holding, dummies for natural disasters and wars and institutional quality. $\boldsymbol{z}_{ijt}$ denotes bilateral time-varying factors, namely Free Trade Agreements and Bilateral investment treaties. Finally, we include country-pair fixed effects γ_{ij} and home country-year fixed effects d_{it} to capture all the time-invariant bilateral factors and time-varying home county factors that may affect the FDI flows.

In addition to the baseline setting, we also use the continuous DID to estimate the effect of epidemic shock with different levels of severity, which may reveal information about the quantitative relationship between the severity of the epidemic and FDI inflows. The two shock dummies are replaced by two continuous variables, namely $Deaths\_Period_{jt}$ ($Affected\_Period_{jt}$) and $Deaths\_After_{jt}$ ($Affected\_After_{jt}$). Specifically, these continuous measures are created by multiplying the $Shock\_Period_{jt}$ and $Shock\_After_{jt}$ dummies with continuous measures of treatment intensity, namely the log of death numbers and log of infection numbers. It is assumed that the more severe the epidemic is, the larger number of death and infections there will be and the more damage and uncertainty there will be.

4.2 | The overall effect of epidemic outbreak on FDI inflows

Next, we examine the overall effect of outbreaks on total FDI inflows, beginning from the outbreak year to the third year after the outbreak. In this way, we try to answer the question raised by Hypothesis 1b: regardless of the fluctuation, is there any loss of FDI due to an epidemic outbreak?

[13]At the current stage, we do not know exactly how long will the epidemic outbreaks' effect would last. Yet, we believe it might be a reasonable starting point to test the long-term effect within 3 years.

[14]Following Frenkel and Walter (2019), we apply inverse hyperbolic sine (IHS) transformation to the value of FDI inflows to prevent outliers from affecting our results.

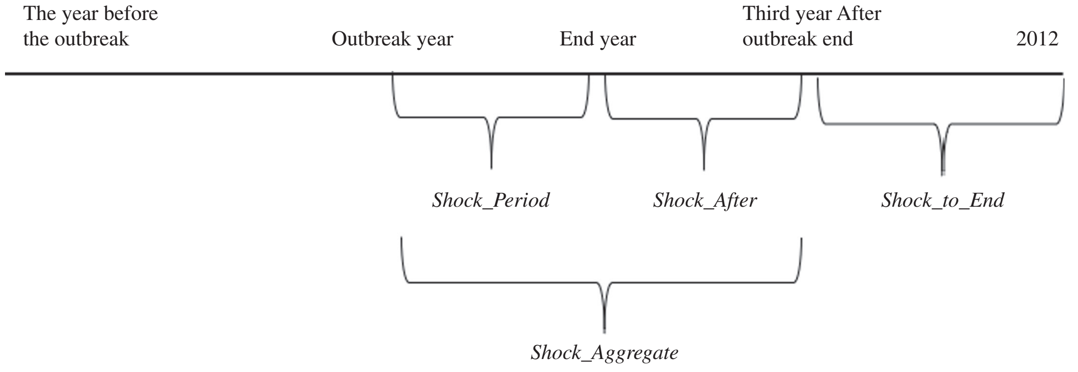

FIGURE 3 The time interval included in each dummy variable. *Note*: This figure shows the time interval included in each dummy variable. We assign $Shock\_Period_{jt}$ a value of 1 if country j experiences an epidemic outbreak in year t; otherwise, we assign it a value of 0. We assign $Shock\_After_{jt}$ a value of 1 if country j had experienced epidemic outbreaks and year t is within 3 years after the end of the epidemic. We assign $Shock\_Aggregate_{jt}$ a value of 1 if country j experiences an epidemic within 3 years of year t; otherwise, we assign it a value of 0. We assign $Shock\_to\_end$ a value of 1 if country j is in the treatment group and year t is during the period from the fourth year after an epidemic to 2012; otherwise, we assign it a value of 0.

The basic setting is close to Equation (1), except that we only include one key variable, $Shock\_Aggregate_{jt}$, this time. The detailed model is listed as follows in Equation (2):

$$FValues_{ijt} = \beta_1 Shock_{Aggregate_{jt}} + \beta_X' \boldsymbol{x}_{jt} + \beta_Z' \boldsymbol{z}_{ijt} + \boldsymbol{\gamma}_{ij} + \boldsymbol{d}_{it} + \varepsilon_{ijt}, \tag{2}$$

where $Shock\_Aggregate_{jt}$ is assigned a value of 1 if country j experiences an epidemic outbreak in any year of t, $t-1$, $t-2$ or $t-3$; otherwise, it will be assigned a value of 0. Therefore, if epidemic outbreaks mainly influence the FDI inflows through uncertainty channels and firms will not cancel their investment but only delay them, the estimated β_1 would be close to zero and insignificant. In addition, we also multiply the overall effect dummy $Shock\_Aggregate_{jt}$ with our continuous measures of treatment intensity, namely the log of death numbers and log of infection numbers in alternative model specifications.

In summary, to investigate both short-run and long-run effects in a detailed way and find clues to the underlying mechanism, we ask three questions and created different dummies to investigate these questions: (i) how will FDI inflows response during the time of epidemic outbreak; (ii) how will the FDI inflows behave in the 3 years after the epidemic outbreak ends and (iii) overall, does an epidemic outbreak cause any loss of inward FDI during the entire cycle? Figure 3 shows how each dummy is created by visualising them on one timeline, which may help to better understand the meaning of each key variable we constructed.

5 | EMPIRICAL RESULTS

We report the main results of this paper in four parts. In the first part, we report baseline results, which test Hypothesis 1a and 1b and investigate how epidemic outbreaks affect FDI flows in the short and long run. The second part reports the results of the industry-level analysis, which addresses Hypothesis 2 and investigates the effectiveness of the uncertainty mechanism. Finally, the third part presents the results of Hypotheses 3a and 3b, which investigate the role of institutional quality and healthcare conditions in the relationship between epidemic outbreaks and inward FDI. In the fourth part, we report robustness checks on the baseline findings.

5.1 | Baseline results

5.1.1 | Short-run, long-run and overall effect on FDI inflows

Table 3 shows the baseline results estimated based on Equations (1) and (2), which aim to explore the short-run, long-run and overall effect of an outbreak on inward FDI. In columns (1)–(3), the key independent variables are two time indicators, namely the *Shock_Period* dummy and *Shock_After* dummy, hence the results in the first three columns compare the outbreak period as well as the 3 years after an outbreak to the normal years.

In column (1), we find that the coefficient of the *Shock_Period* is negative and significant, whereas the coefficient for *Shock_After* is positive and significant. Specifically, FDI inflows decrease significantly by approximately 21.5% during the outbreak but will be significantly higher than the normal period by 21.6% in the 3 years after the end of the outbreak. The positive and significant β_2 not only indicates the recovery of FDI after the epidemic outbreak but also suggests that the surge of FDI after the end of outbreaks is even higher than in normal periods. In other words, this finding confirms the overshooting or compensating increase of FDI inflow. In columns (2) and (3), we use continuous measures of epidemic outbreak shocks, namely ln(deaths) and ln (affected people), and the results remain stable. The directions of the estimated coefficients are the same as column (1), which implies that the more severe the outbreak is, the larger fluctuation of FDI inflows will be. Specifically, with every doubling of death number in the epidemic outbreaks, FDI flows will first be decreased by 4.3% and then increase by 3.7%, compared to the normal period. Every doubling of persons infected will reduce FDI flows by 2.3% at the initial time, but FDI then surges by 2.4% after the end of the epidemic outbreak.

We may be happy to learn from the overshooting of FDI after the end of the outbreaks that some of the suspended investments will be resumed later. But the question still remains: how much of the suspended FDI will be resumed? To explore whether aggregate FDI has suffered any substantial losses, in the long run, we estimate Equation (2), in which we only include one dummy (*Shock_Aggregate*$_{jt}$) that captures the years from the beginning of the epidemic outbreak the third year after the outbreak ends. By doing so, we are comparing these shocked and post-epidemic years with the normal years to identify the overall effect of epidemic outbreaks. The results are reported in columns (4)–(6) of Table 3. We find that the coefficients for the variables *Shock_Aggregate*$_{jt}$, *Deaths_Aggregate*$_{jt}$ and *Affected_Aggregate*$_{jt}$ are all insignificantly different from zero. Hence, we may say that the epidemic outbreaks in host countries would hardly cause a substantial loss of inward FDI in a relatively long-run perspective.

In summary, these results listed in Table 3 reveal that an outbreak in the host country will first cause a sudden fall in FDI inflows but will not reduce FDI inflows in the long term since there will be an overshooting of FDI inflows in the 3 years after the end of the outbreak. Such findings not only shed light on the reaction of inward FDI following an epidemic outbreak in both the short and long run but also suggest the possible underlying mechanism of uncertainty.

5.1.2 | Event study and FDI dynamics

The DID approach above aims to investigate the causal effect of epidemic outbreaks and FDI. We supplement the above study by event study approach (EVA) to serve two purposes: (1) to test the parallel trend hypothesis with the advantage of controlling for covariates and (2) to provide a straightforward picture of the year-by-year effects of epidemic outbreaks on inward FDI.[15]

[15]Therefore, this part of the test is also often referred to in previous literature as dynamic effects on FDI (Autor, 2003; Beck et al., 2010).

TABLE 3 The long-term effect of epidemic outbreak.

	Short-run and long-run effect			Aggregate effect		
	Different measures for epidemic outbreak			Different measures for epidemic outbreak		
	(1)	(2)	(3)	(4)	(5)	(6)
$Shock\_Period_{jt}$	−0.215**					
	(0.109)					
$Shock\_After_{jt}$	0.216**					
	(0.089)					
$Deaths\_Period_{jt}$		−0.043**				
		(0.019)				
$Deaths\_After_{jt}$		0.037**				
		(0.016)				
$Affected\_Period_{jt}$			−0.023*			
			(0.012)			
$Affected\_After_{jt}$			0.024**			
			(0.010)			
$Shock\_Aggregate_{jt}$				0.003		
				(0.082)		
$Deaths\_Aggregate_{jt}$					0.000	
					(0.015)	
$Affected\_Aggregate_{jt}$						0.000
						(0.009)
$\text{Ln}GDP\_cap_{jt}$	0.883***	0.885***	0.883***	0.909***	0.909***	0.909***
	(0.117)	(0.117)	(0.117)	(0.116)	(0.116)	(0.116)
$Openness_{jt}$	−0.002	−0.002	−0.001	−0.001	−0.001	−0.001
	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)
$GovExp_{jt}$	0.020*	0.020*	0.019*	0.019*	0.019*	0.019*
	(0.011)	(0.011)	(0.011)	(0.011)	(0.011)	(0.011)
GDP_Growth_{jt}	0.021***	0.021***	0.021***	0.021***	0.021***	0.021***
	(0.005)	(0.005)	(0.005)	(0.005)	(0.005)	(0.005)
$\text{Ln}ExRate_{jt}$	−0.443**	−0.444**	−0.439*	−0.414*	−0.414*	−0.414*
	(0.224)	(0.224)	(0.224)	(0.224)	(0.224)	(0.224)
$Rent_{jt}$	−0.016**	−0.015**	−0.016**	−0.015**	−0.015**	−0.015**
	(0.007)	(0.007)	(0.007)	(0.007)	(0.007)	(0.007)
$Deflator_{jt}$	0.011***	0.011***	0.011***	0.011***	0.011***	0.011***
	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)
$Patent_{jt}$	0.007**	0.007**	0.007**	0.007***	0.007***	0.007***
	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)

(Continues)

TABLE 3 (Continued)

	Short-run and long-run effect			Aggregate effect		
	Different measures for epidemic outbreak			Different measures for epidemic outbreak		
	(1)	(2)	(3)	(4)	(5)	(6)
FTA_{jt}	0.178**	0.177**	0.178**	0.179**	0.179**	0.179**
	(0.085)	(0.085)	(0.085)	(0.085)	(0.085)	(0.085)
BIT_{ijt}	0.195**	0.195**	0.196**	0.199**	0.199**	0.199**
	(0.094)	(0.094)	(0.094)	(0.094)	(0.094)	(0.094)
$Disaster_{jt}$	−0.115***	−0.114***	−0.114***	−0.106**	−0.106**	−0.106**
	(0.043)	(0.043)	(0.043)	(0.043)	(0.043)	(0.043)
War_{ijt}	−0.632	−0.608	−0.615	−0.614	−0.615	−0.615
	(0.519)	(0.520)	(0.518)	(0.518)	(0.519)	(0.519)
$Regulation_{jt}$	−0.005	−0.006	−0.006	−0.005	−0.005	−0.005
	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)
Control	Y	Y	Y	Y	Y	Y
Country-pair FE	Y	Y	Y	Y	Y	Y
*Home Country FE*Year FE*	Y	Y	Y	Y	Y	Y
R^2	.381	.381	.381	.380	.380	.380
N	42,589	42,589	42,589	42,589	42,589	42,589

Note: This table presents results from Equations (1) and (2). The dependent variable is bilateral FDI flow after IHS transformation. Columns (1)–(3) report the current and lagged impact of the epidemic on FDI based on the combined DID setting, using different measures for epidemic outbreaks. Columns (4)–(6) report the overall effect of epidemic outbreaks on FDI. ***Significant at 1% level, **significant at 5% level and *significant at 10% level.

To implement this exercise, we divide the entire period into eight bins by creating a set of dummies including the treatment period as well as its leads and lags, and then put these dummy variables in the baseline setting:

$$\begin{aligned} FValues_{ijt} &= \beta_1 D_{jt}^{-2} + \beta_2 D_{jt}^{-1} + \beta_3 D_{jt}^{0} + \beta_4 D_{jt}^{1} + \beta_5 D_{jt}^{2} + \beta_6 D_{jt}^{3} + \beta_7 D_{jt}^{4} \\ &+ \beta_X' \boldsymbol{x}_{jt} + \beta_Z' \boldsymbol{z}_{ijt} + \boldsymbol{\gamma}_{ij} + \boldsymbol{d}_{it} + \varepsilon_{ijt}, \end{aligned} \tag{3}$$

where the outbreak dummy variables, the D's, equal zero, except as follows: D^{-k} equals one if the host country is in the kth year before an epidemic outbreak, D^{+k} equals one for host countries in the kth year after an epidemic outbreak, D^0 equals one for host countries being attacked by epidemic outbreaks currently. Hence, we are estimating the dynamic effect of epidemic outbreaks on inward FDI relative to normal years.[16]

In Figure 4, we plot the estimated coefficients and the corresponding 90% confidence intervals, which are adjusted for the country-pair cluster. It is very straightforward to see that inward FDI fluc-

[16]Another problem that needs to explain is that there are also some countries that had not been hit by epidemic outbreaks during our studying period (2000–2012). The existence of such never-treated countries will not affect the DID estimation but may cause problems in this dynamic effect model by reducing sample numbers. To make use of information about these never-treated countries, we assign values of zero to all the dummies for countries not being treated in the entire period. By doing so, we are able to include these countries in the control group in the analysis.

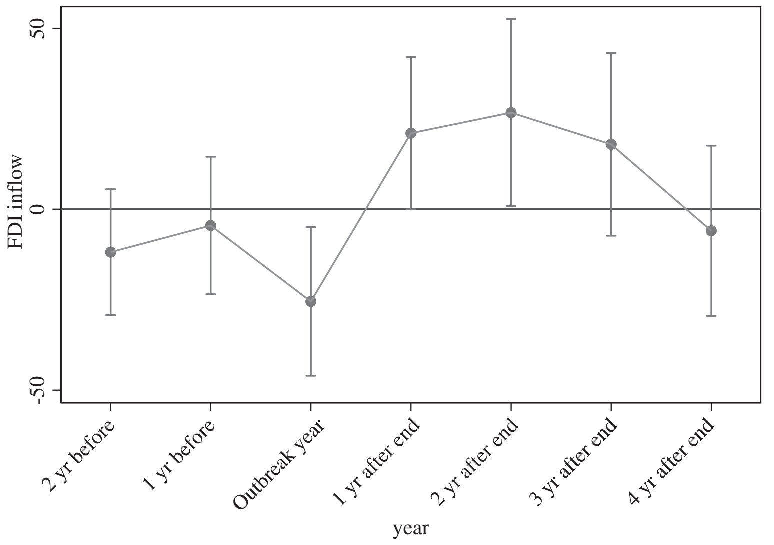

FIGURE 4 Dynamic impact of outbreaks on FDI inflows. *Note*: This figure shows the dynamics of FDI inflows from 2 years before to 4 years or above after the end of an outbreak. The reference year is the pre-treatment period, namely 3 years or more than 3 years before outbreaks. The results are estimated from Equation (3). The vertical lines around the dots indicate the 90% confidence interval.

tuates in an S-shape, featuring the initial quick drop and then overshooting. Specifically, the curve in Figure 4 illustrates four points. First, the parallel trends assumption holds, or there is no significant difference in the growth of FDI inflows between the treatment and control groups before the outbreak since the coefficients of D_{jt}^{-2} and D_{jt}^{-1} are not significantly from zero. Second, the negative effect of an epidemic outbreak on FDI inflows happens in a fast but temporary way, or FDI inflows only drop during the epidemic outbreak years, since the coefficient of D_{jt}^{0} is negative and the coefficient of D_{jt}^{1} is positive and significant. Finally, the FDI inflows overshoot in the following 2 years after the epidemic ends, which means the investments into the host country after the epidemic ends even exceed the level before the shock, since D_{jt}^{1} and D_{jt}^{2} are all positive and significant. Finally, the effect of an epidemic outbreak on FDI inflow, no matter the drop or the following overshooting, fades out 3 years after the end of the epidemic since coefficients of D_{jt}^{3} and D_{jt}^{4} are insignificantly different from zero. Such patterns are consistent with the theories discussing uncertainty's effect on investment (Bernanke, 1983; Bloom, 2009; Rivoli & Salorio, 1996; Rodrik, 1991; Stokey, 2016).

5.2 | Mechanism analysis

The baseline results reported in Section 5.1 provided some hits about the validity of the uncertainty mechanism by showing that inward FDI will overshoot after the end of the epidemic outbreak. In this section, we use industry-level variation in redeployability and investigate Hypothesis 2, in order to verify the effectiveness of the uncertainty mechanism and to identify the industries whose FDIs are most vulnerable to an epidemic outbreak.

The rationale behind Hypothesis 2 is as follows: when the epidemic outbreaks influence the inward FDI by increasing uncertainty in the host country, the negative impact of epidemic outbreaks should be stronger in industries whose investments are more difficult to reverse and thus more vulnerable to uncertainty. To investigate Hypothesis 2, we use the industry-level redeployability index to measure the level of the irreversibility of investment or the sensitivity to uncertainty. A higher level of redeployability is associated with the easier reverse of investments in the industry, which implies the industry is less sensitive to uncertainty.[17] We include the interaction term of this redeployability index and Shock_period dummies in the baseline settings. Finally, we use industry-level bilateral M&A data from the SDC platinum as the dependent variable in this part of the analysis.[18] The regression specification is given in Equation (4):

$$
\begin{aligned}
lnM\&As_{ijkt} &= \beta_1 Shock_{Period\,jt} + \beta_2 Shock\_Period_{jt}{}^{*} Redeployability_k \\
&+ \beta_X' \boldsymbol{x}_{jt} + \beta_Z' \boldsymbol{z}_{ijt} + \boldsymbol{\gamma}_{ij} + \boldsymbol{d}_{it} + \boldsymbol{\sigma}_{kt} + \varepsilon_{ijkt},
\end{aligned}
\tag{4}
$$

where the dependent variable is the log of the total number of M&A projects. Besides the key independent variable *Shock_Period*$_{jt}$, we also include its interaction term with the industry-level redeployability index. Besides, we add industry-year fixed effects ($\boldsymbol{\sigma}_{kt}$) to control for the industry-level time-varying factors that may influence merger and acquisition decisions. Finally, we include all the control variables in the baseline setting.

The results are shown in Table 4. In column (1), we find that the coefficient of the main effect, namely the estimated coefficient of variable *Shock_Period*$_{jt}$ is negative and significant, while the coefficient of the interaction is positive and significant. That is to say, while the inward FDI decreased during the epidemic outbreak on average, the FDI inflows drop less in the industries which use more redeployable assets. In other words, the outbreak has a greater impact on the FDI of industries whose asset are harder to reverse, suggesting that the epidemic outbreak in host countries cause FDI inflows to fluctuate by introducing uncertainty to the economy. In columns (2) and (3), we use the continuous measure of epidemic shocks, namely *Deaths_Period*$_{jt}$ and *Affected_Period*$_{jt}$ to interact with the redeployable index. The conclusions remain unchanged.

5.3 | The heterogeneous effects on FDI fluctuations

Our previous findings suggest that FDI inflows decrease during the epidemic outbreak and overshoot after the end of an epidemic in general. Moreover, we also find that epidemic outbreaks cause FDI inflow fluctuation by increasing uncertainty and that the uncertainty resolves quickly after the epidemic ends in general. However, there could be much heterogeneity in terms of the intensity and duration of inward FDI fluctuation across countries after they have been hit by epidemic outbreaks. In this section, we explore two host country characteristics, healthcare condition, and institutional quality, which may amplify or contain the impact of an epidemic outbreak on FDI fluctuation by testing Hypotheses 3a and 3b.

[17]This index was developed by Kim and Kung (2017) and used by many studies as a measure of irreversibility of the investment (Bonaime et al., 2018; Julio & Yook, 2016).

[18]The detailed introduction about this data source and our cleaning methods on M&A could be found in Appendix 1.

TABLE 4 Mechanism analysis: uncertainty.

	Different measures for epidemic outbreak		
	Dummy	**Log (Death)**	**Log (Affected)**
	(1)	**(2)**	**(3)**
$Shock\_Period_{ijkt}$	−0.079*		
	(0.041)		
$Shock\_Period_{ijkt}*Redeployability_k$	0.096**		
	(0.047)		
$Deaths\_Period_{ijkt}$		−0.015**	
		(0.007)	
$Deaths\_Period_{ijkt}*Redeployability_k$		0.017**	
		(0.008)	
$Affected\_Period_{ijkt}$			−0.005*
			(0.003)
$Affected\_Period_{ijkt}*Redeployability_k$			0.007**
			(0.003)
Control	Y	Y	Y
Country-pair FE	Y	Y	Y
*Home Country FE*Year FE*	Y	Y	Y
Industry-year FE	Y	Y	Y
R^2	.170	.170	.143
N	84,073	84,073	87,114

Note: In this table, we seek to test the mechanism of the uncertainty effect. We sum the number of M&A to the bilateral-industry-year level. The dependent variable is the log of the bilateral M&As at the industry-year level. Column (1) presents the impact of epidemic outbreaks on the interaction term between redeployability and epidemic outbreak dummy. Columns (2) and (3) replace the dummy variables with the log of the death number and the log of the affected number, respectively. ***Significant at 1% level, **significant at 5% level and *significant at 10% level.

5.3.1 | Public health system condition and inward FDI

To test Hypothesis 3a, we use the number of hospital beds per 1000 people in 2000, published by the World Bank's WDI database, to represent country-level medical conditions. We create the dummy bed_2000_j as the indicator of better-developed healthcare conditions. We set bed_2000_j to one if the per capita number of hospital beds in a country j in 2000 was above the median; otherwise, we assign it a value of 0. We then interact the dummy of the good healthcare condition (bed_2000_j) with the $Shock\_Period_{jt}$ variable and $Shock\_After_{jt}$ variable.

The results are shown in Table 5. Column (1) shows that the main effect of *Shock_Period* is negative and significant, while the coefficient of the interaction term between $Shock\_Period_{jt}$ and the indicator of better healthcare condition (bed_2000_j), is significantly positive, which suggests that better healthcare can effectively alleviate the initial negative impact of an epidemic on FDI inflow. On the other hand, the estimated coefficients of both the main effect of the *Shock_After* dummy and its interaction term with bed_2000_j are all positive but insignificant, which suggests that healthcare conditions have little influence on how FDI recovers after the epidemic ends. In columns (2) and (3), we change the *Shock_Period* and *Shock_After* dummies into the continuous measure of an epidemic outbreak, namely the log of death number and the log of infection number, and get the same conclusion.

TABLE 5 Heterogeneity of medical condition

	Different measures for epidemic outbreak		
	Shock dummy	Ln (Deaths)	Ln (Affected)
	(1)	(2)	(3)
$Shock\_Period_{jt}$	−0.554***	−0.092***	−0.056**
	(0.200)	(0.034)	(0.023)
$Shock\_Period_{jt}$ *BED_2000	0.268*	0.047*	0.027*
	(0.143)	(0.026)	(0.015)
$Shock\_After_{jt}$	0.038	0.002	−0.002
	(0.179)	(0.030)	(0.020)
$Shock\_After_{jt}$ *BED_2000	0.119	0.024	0.014
	(0.116)	(0.021)	(0.013)
Control	Y	Y	Y
Country-pair FE	Y	Y	Y
Home Country-Year FE	Y	Y	Y
R^2	.374	.374	.374
N	37,015	37,015	37,015

Note: In this table, we test the heterogeneity of healthcare conditions. The dependent variable is bilateral FDI flows after IHS transformation. Column (1) presents the results from interacting the outbreak dummy with the number of hospital beds per 1000 people in 2000. Columns (2) and (3) replace the dummy variables with the number of deaths and infections, respectively. ***Significant at 1% level, **significant at 5% level and *significant at 10% level.

A good healthcare system not only directly mitigates the influence of epidemic outbreaks on social and economic activities but also alleviates the upgrading of uncertainty. Without worrying about the disease and future economy, firms' investment decisions from a long-run perspective are unlikely to change. They may continue their investment projects even during the epidemic outbreak, making the FDI inflow relatively stable over the entire cycle.

5.3.2 | Institutional quality and inward FDI

To test Hypothesis 3b, we use the institutional quality index from WGI. In particular, we choose the measure of regulatory quality to reflect the ability of the government to formulate and implement sound policies and regulations that promote private sector development (Kaufmann et al., 2010). Specifically, we create an indicator for poor regulation quality, $PoorRegulation_j$. We assign this dummy value of 1 when the country j's regulation quality in the year 2000 is below the median; otherwise, we assign it a value of 0.[19] Similar to the last section, we include our key shock dummies as well as their interactions with this poor regulation quality indicator in our baseline setting.

The results are shown in Table 6. According to column (1), the estimated coefficients of both the *Shock_Period* dummy and its interaction term with *PoorRegulation* are all negative and insignificant, suggesting no significant difference in the initial drop of FDI between countries with different regulation qualities. However, we find the compensatory FDI rebound after the epidemic in countries with poor regulation quality is significantly weaker than that in countries with good regulation quality

[19]We use the index in the year 2000, which is 1 year previous to our data sample period.

TABLE 6 Heterogeneity of institutional quality.

	Different measures for epidemic outbreak		
	Shock dummy	**Ln (Deaths)**	**Ln (Affected)**
	(1)	**(2)**	**(3)**
$Shock\_Period_{jt}$	−0.251	−0.048	−0.027
	(0.222)	(0.039)	(0.028)
$Shock\_Period_{jt}*PoorRegulation$	0.026	0.001	0.003
	(0.254)	(0.045)	(0.031)
$Shock\_After_{jt}$	0.453***	0.082***	0.059***
	(0.172)	(0.030)	(0.022)
$Shock\_After_{jt}*PoorRegulation$	−0.409**	−0.078**	−0.053**
	(0.204)	(0.036)	(0.026)
Control	Y	Y	Y
Country-pair FE	Y	Y	Y
*Home Country FE*Year FE*	Y	Y	Y
R^2	.381	.381	.381
N	42,589	42,589	42,589

Note: In this table, we test the heterogeneity of institutional quality. The dependent variable is bilateral FDI flows after IHS transformation. Column (1) presents the results from interacting the outbreak dummy with institutional quality. Columns (2) and (3) replace the dummy variables with the number of deaths and number of infections, respectively. ***significant at 1% level, **significant at 5% level and *significant at 10% level.

since the coefficient of *Shock_After* is significantly positive, and the coefficient of the interaction term is negative and significant. In short, the affected countries with relatively good regulation quality experience an S-shaped fluctuation, featuring the initial drop and then overshooting of inward FDI. In contrast, countries with poor regulation quality can hardly recover, not to mention overshooting. Our conclusions are consistent with the recent findings that countries with poorer institutions are slower to recover after epidemics (Agrawala et al., 2020).

Faced with risk and uncertainty brought about by epidemic outbreaks, firms' decisions on whether to suspend the investment do not rely too much on government regulation quality. On the other hand, it is the recovery period when regulation really matters. It seems that the epidemic outbreaks could deter the attractiveness of FDI for a very long time when the regulation quality is poor. Perhaps, when no effective regulations are made, the epidemic would bring sequelae or bad aftermath, which will adversely influence the economy for a long time.

5.4 | Robustness tests

We conduct a series of robustness checks about the baseline findings in response to the concerns about selection bias, pre-treatment parallel assumption, alternative explanations and different types of international investment. The associated results are reported in this section.

5.4.1 | Selection bias

Parallel trend assumption is critical to the identification of causal effects in DID settings. When such an assumption is violated, or there are systematic differences between the treatment and control groups, OLS estimation with the same weights for all samples could be biased (Cicala, 2015; Fqwlie et al., 2012). We have verified this assumption in the previous dynamic analysis. This section provides two alternative ways to address this concern: PSM-DID and IPW-DID.[20] We choose the country's FDI inflow in 2000, 1 year before our sample period, as a matching variable.[21] Columns (1)–(3) in Table 7 show the results using the PSM-DID method; we find that the main conclusions of this paper remain unchanged. Similarly, in columns (4)–(6), our baseline conclusion remains unchanged when we adopt the IPW-DID method.

5.4.2 | Elimination of trend factors

A potential alternative explanation for the overshooting of FDI after the epidemic outbreaks is the possible existence of growing trends in the treatment group's inward FDI. To exclude the influence of trend factors, we investigate the behaviours of inward FDI from the fourth year after the epidemic to the end of the sample period by adding a dummy of *Shock_to_End* to the baseline model of Equation (1). The *Shock_to_End* dummy is set to 1 in country j in year t is in the fourth or above year after the epidemic outbreak. In this way, we estimate the effect of epidemic outbreaks on FDI referring to the pre-treatment periods. Therefore, if the overshooting of FDI in the following 3 years after the epidemic results from the increasing trends, we would obtain a positive and significant coefficient for the *Shock_to_End* dummy. Otherwise, the coefficient should be insignificant from zero.

The results are shown in Table 8. The estimated coefficients for the *Shock_to_End* period are insignificant, indicating no significant difference in growth trends between the treatment and control groups during this period, which excludes the possibility that compensatory FDI results from a growing trend within the treated group.

Besides the above robustness checks, we use M&A data from SDC Platinum to re-run the baseline regressions. The findings remain stable. The detailed results can be found in Appendix 1.

6 | CONCLUSION

This paper examines how epidemic outbreaks in host countries affect their inward FDI. Using historical data on FDI and epidemic outbreaks, we find that epidemic outbreaks cause FDI inflows to fluctuate in an S-shaped curve, which is featured with a sharp initial drop and an overshooting afterwards. Moreover, the epidemic outbreaks act as temporal shocks and do not cause substantial loss of inward FDI in the long term. Such a result also suggests the effectiveness of the uncertainty mechanism: investors may wait until the uncertainty brought by epidemic outbreaks resolves. Next, we use industry-level variation in redeployability to investigate the uncertainty mechanism and find that inward FDI in industries with more easily redeployed assets drops less during the epidemic outbreaks. Finally, we examine country characteristics that may become particularly important in influencing inward FDI during epidemic outbreaks. We find that healthcare conditions significantly exacerbate the negative effect of epidemic outbreaks on FDI during the outbreak period and that poorer institutional quality hinders recoveries of FDI after epidemics end.

[20]One of the advantages of PSM-DID is that it allows for more accurate between-group comparisons through 1:1 neighbour matching. The advantage of IPW-DID is that it does not remove samples and uses propensity-matching scores as weights for DID estimation.

[21]Results of PSM passed the balance test but were not included in the text due to space constraints.

TABLE 7 Dealing with selection bias

	PSM_DID			*IPW_DID*		
	Different measures for epidemic outbreak			**Different measures for epidemic outbreak**		
	Dummy	**Log (Death)**	**Log (Affected)**	**Dummy**	**Log (Death)**	**Log (Affected)**
	(1)	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**
Shock_Period$_{jt}$	−0.248**			−0.239**		
	(0.118)			(0.099)		
Shock_After$_{jt}$	0.204*			0.159		
	(0.108)			(0.099)		
Deaths_Period$_{jt}$		−0.048**			−0.043**	
		(0.021)			(0.018)	
Deaths_After$_{jt}$		0.036*			0.058***	
		(0.019)			(0.020)	
Affected_Period$_{jt}$			−0.028**			−0.022**
			(0.013)			(0.011)
Affected_After$_{jt}$			0.024*			0.032***
			(0.012)			(0.012)
Control	Y	Y	Y	Y	Y	Y
Country-pair FE	Y	Y	Y	Y	Y	Y
*Home Country FE*Year FE*	Y	Y	Y	Y	Y	Y
R^2	.460	.460	.460	.523	.524	.524
N	11,889	11,889	11,889	40,935	40,935	40,935

Note: This table presents the results of the selection bias test. The dependent variable is bilateral FDI flows after IHS transformation. We choose a country's FDI inflow in 2000 as the matching variable. Columns (1)–(3) show the results of the PSM-DID method. Columns (4)–(6) show the results of the IPW-DID method. ***significant at 1% level, **significant at 5% level and *significant at 10% level.

These findings help to understand the dynamics of inward FDI when an epidemic outbreak hits the host country. In addition, they may have policy implications. First of all, even though the effect of epidemic outbreaks on inward FDI is temporal on average, the government should be alerted that they may cause substantial negative consequences in some circumstances: (i) epidemic outbreaks significantly increase the volatility of inward FDI, which further threats the stability of the macroeconomy and (ii) the impact varies across countries and industries. When the medical conditions are poor, the negative effects could be amplified. Moreover, the temporal shock could become a long-term unfavourable factor that hinders the recovery of FDI, when the regulation quality in the host country is poor.

Moreover, by clearly understanding the epidemics' impact on inward FDI and being aware of the potential negative consequences, the government may make endeavours to alleviate the negative effect and stabilise the inward FDI, which may further contribute to the stability of macroeconomy: (i) making a greater investment in public health systems may help to reduce the initial drop and fluctuation of inward FDI; (ii) to facilitate the recovery of FDI, the government should improve their regulation quality by reducing regulation burden, improving competitive practices, reducing excessive protection, and improving taxation consistency, etc. and (iii) government may need to make targeted

TABLE 8 Alternative explanation 2: trend factors.

	Different measures for epidemic outbreak		
	Dummy	**Log (Death)**	**Log (Affected)**
	(1)	**(2)**	**(3)**
$Shock\_Period_{jt}$	−0.227**		
	(0.113)		
$Shock\_After_{jt}$	0.237*		
	(0.122)		
Shock_to_End	−0.044		
	(0.141)		
$Deaths\_Period_{jt}$		−0.046**	
		(0.021)	
$Deaths\_After_{jt}$		0.042**	
		(0.021)	
Deaths_to_End		−0.010	
		(0.025)	
$Affected\_Period_{jt}$			−0.024*
			(0.013)
$Affected\_After_{jt}$			0.026*
			(0.014)
Affected_to_End			−0.005
			(0.016)
Control	Y	Y	Y
Country-pair FE	Y	Y	Y
*Home Country FE*Year FE*	Y	Y	Y
R^2	.381	.381	.381
N	42,589	42,589	42,589

Note: This table excludes trend factors as alternative explanations. The dependent variable is bilateral FDI flows after IHS transformation. Column (1) includes an additional dummy variable indicating the period from the fourth year after the end of an epidemic to the last year of our sample period in our baseline setting. Columns (2) and (3) replace the dummy variables with the number of deaths and number of infections, respectively. ***significant at 1% level, **significant at 5% level and *significant at 10% level.

assistance policies to the investment in industries whose assets are hard to be redeployed, in order to mitigate FDI volatility and improve FDI stability.

This paper has a few limitations, which also provide opportunities for further research. First, due to data limitations, our study only explores local-scale epidemics but not global pandemics. Hence, whether the S-shaped FDI fluctuations exist under a global pandemic when most countries are influenced needs to be reconsidered. Second, we mainly focus on medical conditions and institutional quality to explore the heterogeneous effect. Many other country characteristics, such as culture, politics, and the media, may also influence the effect of the epidemic on inward FDI. Finally, this paper addresses the impact of epidemics on FDI volatility. The future study may explore the impact of epidemics on FDI entry patterns, FDI earnings, MNC earnings and supply chain composition, etc. as well.

ACKNOWLEDGEMENTS

We thank the anonymous referees and the editor for their suggestions and guidance. We are grateful for suggestions from Zhihong Yu, Bin Sheng, Qilin Mao, Ruifei Guo, Xun Li, Shengjun Jiang, Xiaoguang Liu, James Zhan, and seminar and conference participants at Zhejiang University, Nankai University, Tsinghua University, Renmin University of China, 2022 Academy of International Business (AIB) Annual Conference. Zhen Yu gratefully acknowledges funding support from the National Office for Philosophy and Social Sciences (grant number: 20VYJ035, 16ZDA039). Jing Zhao gratefully acknowledges funding support from the Ministry of Education of China (grant number: 2020-N45). Any errors are our own.

DATA AVAILABILITY STATEMENT

The data in our paper were from the following public domain resources: https://www.emdat.be/; https://unctad.org/topic/investment/investment-statistics-and-trends; https://databank.worldbank.org/source/world-development-indicators; https://investmentpolicy.unctad.org/international-investment-agreements; https://www.wto.org/english/tratop_e/region_e/region_e.htm; http://info.worldbank.org/governance/wgi/.

ORCID

Jing Zhao https://orcid.org/0000-0001-8369-6442

REFERENCES

Aassve, A., Alfani, G., Gandolfi, F., & Le Moglie, M. (2020). *Epidemics and trust: The case of the Spanish flu*. NBER working paper.

Acemoglu, D., & Johnson, S. (2007). Disease and development: The effect of life expectancy on economic growth. *Journal of Political Economy*, *115*(6), 925–985. https://doi.org/10.1086/529000

Acemoglu, D., & Johnson, S. (2014). Disease and development: A reply to bloom, canning, and fink. *Journal of Political Economy*, *122*(6), 1367–1375.

Agrawala, S., Dussaux, D., & Monti, N. (2020). *What policies for greening the crisis response and economic recovery?: Lessons learned from past green stimulus measures and implications for the COVID-19 crisis*.

Ahir, H., Bloom, N., & Furceri, D. (2018). The world uncertainty index. *SSRN Electronic Journal*. https://doi.org/10.2139/ssrn.3275033

Aisbett, E. (2017). Bilateral investment treaties as deterrents of host- country discretion: The impact of investor-state disputes on foreign direct investment in developing countries. *Review of World Economics*, *154*, 119–155. https://doi.org/10.1007/s10290-017-0285-1

Al-Thaqeb, S. A., Algharabali, B. G., & Alabdulghafour, K. T. (2020). The pandemic and economic policy uncertainty. *International Journal of Finance and Economics*, *27*, 2784–2794. https://doi.org/10.1002/ijfe.2298

Alfaro, L., Kalemli-Ozcan, S., & Volosovych, V. (2008). Why doesn't capital flow from rich to poor countries? An empirical investigation. *Review of Economics and Statistics*, *90*(2), 347–368. https://doi.org/10.1162/rest.90.2.347

Altig, D., Baker, S., Maria, J., Bloom, N., Bunn, P., Chen, S., Davis, S. J., Leather, J., Meyer, B., Mihaylov, E., Mizen, P., Parker, N., Renault, T., Smietanka, P., & Thwaites, G. (2020). Economic uncertainty before and during the COVID-19 pandemic. *Journal of Public Economics*, *191*, 104274. https://doi.org/10.1016/j.jpubeco.2020.104274

Ambrus, A., Field, E., & Gonzalez, R. (2020). Loss in the time of cholera: Long-run impact of a disease epidemic on the urban landscape. *American Economic Review*, *110*(2), 475–525. https://doi.org/10.1257/aer.20190759

Autor, D. H. (2003). Outsourcing at will: The contribution of unjust dismissal doctrine to the growth of employment outsourcing. *Journal of Labor Economics*, *21*(1), 1–42.

Azzimonti, M. (2019). Does partisan conflict deter FDI inflows to the US? *Journal of International Economics*, *120*, 162–178. https://doi.org/10.1016/j.jinteco.2019.06.001

Bénassy-Quéré, A., Coupet, M., & Mayer, T. (2007). Institutional determinants of foreign direct investment. *The World Economy*, *30*, 764–782. https://doi.org/10.1111/j.1467-9701.2007.01022.x

Baker, M., Foley, C. F., & Wurgler, J. (2009). Multinationals as arbitrageurs: The effect of stock market valuations on foreign direct investment. *Review of Financial Studies*, *22*(1), 337–369. https://doi.org/10.1093/rfs/hhn027

Baker, S. R., Bloom, N., & Davis, S. J. (2016). Measuring economic policy uncertainty. *Quarterly Journal of Economics*, *131*(4), 1593–1636. https://doi.org/10.1093/qje/qjw024

Baldwin, R., & di Mauro, B. W. (2020). *Economics in the time of COVID-19*. www.cepr.org

Baranov, V., & Kohler, H. P. (2018). The impact of AIDS treatment on savings and human capital investment in Malawi. *American Economic Journal: Applied Economics*, *10*(1), 266–306. https://doi.org/10.1257/app.20150369

Beck, T., Levine, R., & Levkov, A. (2010). Big bad banks? The winners and losers from bank deregulation in the United States. *Journal of Finance*, *65*(5), 1637–1667. https://doi.org/10.1111/j.1540-6261.2010.01589.x

Bernanke, B. S. (1983). Irreversibility, uncertainty, and cyclical investment. *The Quarterly Journal of Economics*, *98*(1), 85. https://doi.org/10.2307/1885568

Bhattacharya, U., Hsu, P. H., Tian, X., & Xu, Y. (2017). What affects innovation more: Policy or policy uncertainty? *Journal of Financial and Quantitative Analysis*, *52*(5), 1869–1901. https://doi.org/10.1017/S0022109017000540

Bish, A., & Michie, S. (2010). Demographic and attitudinal determinants of protective behaviours during a pandemic: A review. *British Journal of Health Psychology*, *15*, 797–824. https://doi.org/10.1348/135910710X485826

Blonigen, B. A., & Piger, J. (2014). Determinants of foreign direct investment. *Canadian Journal of Economics*, *47*(3), 775–812. https://doi.org/10.1111/caje.12091

Bloom, D. E., Canning, D., & Fink, G. (2014). Comments disease and development revisited. *Journal of Political Economy*, *122*(6), 1355–1366.

Bloom, D. E., Canning, D., Kotschy, R., Prettner, K., & Schünemann, J. J. (2019). *Health and economic growth: Reconciling the micro and macro evidence*. NBER working paper, 6, 623–682. https://doi.org/10.1016/B978-0-444-53540-5.00003-3

Bloom, D. E., & Mahal, A. S. (1997). Does the AIDS epidemic threaten economic growth? *Journal of Econometrics*, *77*(1), 105–124. https://doi.org/10.1016/S0304-4076(96)01808-8

Bloom, D. E., Sachs, J. D., Collier, P., & Udry, C. (1998). Geography, demography, and economic growth in Africa. *Brookings Papers on Economic Activity*, *1998*(2), 207–295.

Bloom, N. (2009). The impact of uncertainty shocks. *Econometrica*, *77*(3), 623–685. https://doi.org/10.3982/ecta6248

Bonaime, A., Gulen, H., & Ion, M. (2018). Does policy uncertainty affect mergers and acquisitions? *Journal of Financial Economics*, *129*(3), 531–558. https://doi.org/10.1016/j.jfineco.2018.05.007

Chan, J. M. L., & Zheng, H. (2017). Migrant networks, Greenfield FDI, and cross-border mergers and acquisitions. *SSRN Electronic Journal*, 57.

Chen, M. X., & Lin, C. (2020). Geographic connectivity and cross-border investment: The belts, roads and skies. *Journal of Development Economics*, *146*, 102469. https://doi.org/10.1016/j.jdeveco.2020.102469

Chi, T., Li, J., Trigeorgis, L. G., & Tsekrekos, A. E. (2019). Real options theory in international business. *Journal of International Business Studies*, *50*(4), 525–553. https://doi.org/10.1057/s41267-019-00222-y

Child, J., & Rodrigues, S. B. (2005). The internationalization of Chinese firms: A case for theoretical extension? *Management and Organization Review*, *1*(3), 381–410.

Cicala, S. (2015). When does regulation distort costs? Lessons from fuel procurement in US electricity generation. *American Economic Review*, *105*(1), 411–444. https://doi.org/10.1257/aer.20131377

Clark, D. V., Kibuuka, H., Millard, M., Wakabi, S., Lukwago, L., Taylor, A., Eller, M. A., Eller, L. A., Michael, N. L., Honko, A. N., Olinger, G. G., Jr., Schoepp, R. J., Hepburn, M. J., Hensley, L. E., & Robb, M. L. (2015). Long-term sequelae after Ebola virus disease in Bundibugyo, Uganda: A retrospective cohort study. *The Lancet Infectious Diseases*, *15*(8), 905–912.

Cui, R., Li, M., & Li, Q. (2019). Value of high-quality logistics: Evidence from a clash between SF express and Alibaba. *Management Science*, *66*, 3879–3902. https://doi.org/10.1287/mnsc.2019.3411

Dahl, C. M., Hansen, C. W., & Jensen, P. S. (2020). The 1918 epidemic and a V-shaped recession: Evidence from municipal income data. *Covid Economics*, *6*(6), 137–162.

Daude, C., & Stein, E. (2007). The quality of institutions and foreign direct investment. *Economics & Politics*, *19*(3), 317–344. https://doi.org/10.1111/j.1468-0343.2007.00318.x

Dew-Becker, I., & Giglio, S. (2020). *Cross-sectional uncertainty and the business cycle: Evidence from 40 years of options data*. National Bureau of Economic Research.

Dixit, A. (1989). Entry and exit decisions under uncertainty. *Journal of Political Economy*, *97*(3), 620–638. https://doi.org/10.1086/261619

Driffield, N., & Chiang, P. C. (2009). The effects of offshoring to China: Reallocation, employment and productivity in Taiwan. *International Journal of the Economics of Business*, *16*(1), 19–38.

Eichenbaum, M. S., Rebelo, S., & Trabandt, M. (2021). The macroeconomics of epidemics. *The Review of Financial Studies*, *34*(11), 5149–5187.

Fauci, A. S., Lane, H. C., & Redfield, R. R. (2020). Covid-19 – Navigating the uncharted. *New England Journal of Medicine*, *382*(13), 1268–1269. https://doi.org/10.1056/nejme2002387

Finley, T., & Koyama, M. (2018). Plague, politics, and pogroms: The black death, the rule of law, and the persecution of jews in the holy roman empire. *Journal of Law and Economics*, *61*(2), 253–277. https://doi.org/10.1086/699016

Forbes, K. J., & Warnock, F. E. (2012). Capital flow waves: Surges, stops, flight, and retrenchment. *Journal of International Economics*, *88*(2), 235–251. https://doi.org/10.1016/j.jinteco.2012.03.006

Fortson, J. G. (2011). Mortality risk and human capital investment: The impact of HIV/AIDS in sub-Saharan Africa. *Review of Economics and Statistics*, *93*(1), 1–15. https://doi.org/10.1162/REST_a_00067

Fqwlie, M., Holland, S. P., & Mansur, E. T. (2012). What do emissions markets deliver and to whom? Evidence from Southern California's NO X trading program. *American Economic Review*, *102*(2), 965–993. https://doi.org/10.1257/aer.102.2.965

Frenkel, M., & Walter, B. (2019). Do bilateral investment treaties attract foreign direct investment? The role of international dispute settlement provisions. *World Economy*, *2017*, 1316–1342. https://doi.org/10.1111/twec.12743

Fu, Y., Alleyne, A., & Mu, Y. (2021). Does lockdown bring shutdown? Impact of the COVID-19 pandemic on foreign direct investment. *Emerging Markets Finance and Trade*, *57*, 2792–2811. https://doi.org/10.1080/1540496x.2020.1865150

Gassebner, M., Keck, A., & Robert, T. (2006). *The impact of disasters on international trade*. World Trade Organization working paper.

Gelos, R. G., & Wei, S.-J. (2005). Transparency and international portfolio holdings. *The Journal of Finance*, *60*(6), 2987–3020. https://doi.org/10.1111/j.1540-6261.2005.00823.x

Gonzalez-Torres, A., & Esposito, E. (2020). Epidemics and conflict: Evidence from the Ebola outbreak in Western Africa. *SSRN Electronic Journal*, 1–93.

Gujrati, R., & Uygun, H. (2020). COVID-19 impact on foreign direct investment. *Conference: Covid-19 impact on foreign direct investment and various sectors, India*, 19–24.

Gulen, H., & Ion, M. (2016). Policy uncertainty and corporate investment. *Review of Financial Studies*, *29*(3), 523–564. https://doi.org/10.1093/rfs/hhv050

Hassan, T. A., Hollander, S., Van Lent, L., Schwedeler, M., & Tahoun, A. (2020). *Firm-level exposure to epidemic diseases: Covid-19, SARS, and H1N1*. National Bureau of Economic Research.

Helpman, E. (1984). A simple theory of international trade with multinational corporations. *Journal of Political Economy*, *92*(3), 451–471.

Hines, J. R. (1996). *Tax policy and the activities of multinational corporations*. NBER working paper.

Hitt, M. A., Holmes, R. M., & Arregle, J. L. (2021). The (COVID-19) pandemic and the new world (dis)order. *Journal of World Business*, *56*(4), 101210. https://doi.org/10.1016/j.jwb.2021.101210

Huang, Y., & Wang, B. (2013). Investing overseas without moving factories abroad: The case of Chinese outward direct investment. *Asian Development Review*, *30*(1), 85–107. https://doi.org/10.1162/adev_a_00004

Jedwab, R., Johnson, N. D., & Koyama, M. (2019). Negative shocks and mass persecutions: Evidence from the black death. *Journal of Economic Growth*, *24*(4), 345–395. https://doi.org/10.1007/s10887-019-09167-1

Julio, B., & Yook, Y. (2012). Political uncertainty and corporate investment cycles. *Journal of Finance*, *67*(1), 45–84. https://doi.org/10.1111/j.1540-6261.2011.01707.x

Julio, B., & Yook, Y. (2016). Policy uncertainty, irreversibility, and cross-border flows of capital. *Journal of International Economics*, *103*, 13–26. https://doi.org/10.1016/j.jinteco.2016.08.004

Karlsson, M., Nilsson, T., & Pichler, S. (2014). The impact of the 1918 Spanish flu epidemic on economic performance in Sweden. An investigation into the consequences of an extraordinary mortality shock. *Journal of Health Economics*, *36*(1), 1–19. https://doi.org/10.1016/j.jhealeco.2014.03.005

Kaufmann, D., Aart, K., & Mastruzzi, M. (2010). *The worldwide governance indicators methodology and analytical issues*. Policy Research working paper.

Khoury, T. A., & Peng, M. W. (2011). Does institutional reform of intellectual property rights lead to more inbound FDI? Evidence from Latin America and the Caribbean. *Journal of World Business*, *46*(3), 337–345. https://doi.org/10.1016/j.jwb.2010.07.015

Kim, H., & Kung, H. (2017). The asset redeployability channel: How uncertainty affects corporate investment. *Review of Financial Studies*, *30*(1), 245–280. https://doi.org/10.1093/rfs/hhv076

Lee, S. H., & Makhija, M. (2009). The effect of domestic uncertainty on the real options value of international investments. *Journal of International Business Studies*, *40*(3), 405–420. https://doi.org/10.1057/jibs.2008.79

Li, J., Meyer, K. E., Zhang, H., & Ding, Y. (2018). Diplomatic and corporate networks: Bridges to foreign locations. *Journal of International Business Studies*, *49*(6), 743–752. https://doi.org/10.1057/s41267-017-0098-4

Li, Q. (2010). Dyadic military conflict, security alliances, and bilateral FDI flows. *Journal of International Business Studies*, *41*(5), 765–782. https://doi.org/10.1057/jibs.2009.91

Lipsey, R. E., & Weiss, M. Y. (1984). Foreign production and exports of individual firms. *The Review of Economics and Statistics*, *66*(2), 304. https://doi.org/10.2307/1925832

Markusen, J. R. (1995). The boundaries of multinational enterprises and the theory of international trade. *Journal of Economic Perspectives*, *9*(2), 169–189. https://doi.org/10.1257/jep.9.2.169

McDonald, S., & Roberts, J. (2006). AIDS and economic growth: A human capital approach. *Journal of Development Economics*, *80*(1), 228–250. https://doi.org/10.1016/j.jdeveco.2005.01.004

McKibbin, W., & Fernando, R. (2021). The global macroeconomic impacts of COVID-19: Seven scenarios. *Asian Economic Papers*, *20*(2), 1–30.

Nguyen, N. H., & Phan, H. V. (2017). Policy uncertainty and mergers and acquisitions. *Journal of Financial and Quantitative Analysis*, *52*(2), 613–644.

Nielsen, B. B., Asmussen, C. G., & Weatherall, C. D. (2017). The location choice of foreign direct investments: Empirical evidence and methodological challenges. *Journal of World Business*, *52*(1), 62–82. https://doi.org/10.1016/j.jwb.2016.10.006

Nocke, V., & Yeaple, S. (2007). Cross-border mergers and acquisitions vs. greenfield foreign direct investment: The role of firm heterogeneity. *Journal of International Economics*, *72*(2), 336–365. https://doi.org/10.1016/j.jinteco.2006.09.003

Oh, C. H., Oetzel, J., Rivera, J., & Lien, D. (2020). Natural disasters and MNC sub-national investments in China. *Multinational Business Review*, *28*(2), 245–274. https://doi.org/10.1108/MBR-02-2020-0044

Papaioannou, E. (2009). What drives international financial flows? Politics, institutions and other determinants. *Journal of Development Economics*, *88*(2), 269–281. https://doi.org/10.1016/j.jdeveco.2008.04.001

Parker, C., Ramdas, K., & Savva, N. (2016). Is it enough? Evidence from a natural experiment in India's agriculture markets. *Management Science*, *62*(9), 2481–2503. https://doi.org/10.1287/mnsc.2015.2270

Poelhekke, S., & van der Ploeg, F. (2013). Do natural resources attract nonresource FDI? *Review of Economics and Statistics*, *95*(3), 1046–1065. https://doi.org/10.1162/rest_a_00292

Qualls, N., Levitt, A., Kanade, N., Wright-Jegede, N., Dopson, S., Biggerstaff, M., Reed, C., Uzicanin, A., Levitt, A., Dopson, S., Frank, M., Holloway, R., Koonin, L., Rasmussen, S., Redd, S., de la Motte Hurst, C., Kanade, N., Qualls, N., … Rainey, J. (2017). Community mitigation guidelines to prevent pandemic influenza — United States, 2017. *MMWR. Recommendations and Reports*, *66*(1), 1–34. https://doi.org/10.15585/mmwr.rr6601a1

Reinhart, C. M., & Reinhart, V. R. (2008). Capital flow bonanzas: An encompassing view of the past and present. *NBER Working Paper*, *5*(1), 9–62. https://doi.org/10.1086/595995

Rivoli, P., & Salorio, E. (1996). Foreign direct investment and investment under uncertainty. *Journal of International Business Studies*, *27*(2), 335–357.

Rodrik, D. (1991). Policy uncertainty and private investment in developing countries. *Journal of Development Economics*, *36*(2), 229–242. https://doi.org/10.1016/0304-3878(91)90034-S

Rohra, N., & Chawla, K. (2015). Motives behind mergers & acquisitions: Theory & critical review of literature. *EPRA International Journal of Economic and Business Review*, *3*(4), 5.

Sawchuk, L. A. (2020). Deconstructing an epidemic: Cholera in Gibraltar. In *Plagues and epidemics* (pp. 95–117). Routledge.

Sharma, P., Leung, T. Y., Kingshott, R. P. J., Davcik, N. S., & Cardinali, S. (2020). Managing uncertainty during a global pandemic: An international business perspective. *Journal of Business Research*, *116*, 188–192. https://doi.org/10.1016/j.jbusres.2020.05.026

Stokey, N. L. (2016). Wait-and-see: Investment options under policy uncertainty. *Review of Economic Dynamics*, *21*, 246–265. https://doi.org/10.1016/j.red.2015.06.001

Wei, S. (2000). How taxing is corruption on international investors? *The Review of Economics and Statistics*, *82*, 1–11.

Xing, Y. (2006). Why is China so attractive for FDI? The role of exchange rates. *China Economic Review*, *17*(2), 198–209. https://doi.org/10.1016/j.chieco.2005.10.001

Yu, Z., Li, Y., & Xie, X. (2021). Long-term trade impact of epidemic outbreaks: Is it V-shaped? *Economic Analysis and Policy*, *71*(299), 16–40. https://doi.org/10.1016/j.eap.2021.04.003

Yu, Z., Xiao, Y., & Li, Y. (2020). The response of the labor force participation rate to an epidemic: Evidence from a cross- country analysis. *Emerging Markets Finance and Trade*, *56*(10), 2390–2407. https://doi.org/10.1080/1540496X.2020.1787149

How to cite this article: Yu, Z., Li, Y., & Zhao, J. (2023). Epidemic outbreak and foreign direct investment fluctuation. *The World Economy*, *46*, 1051–1081. https://doi.org/10.1111/twec.13390

APPENDIX 1: ROBUSTNESS CHECK: USING M&A DATA

To address the concern that different types of FDI might react to epidemic outbreaks differently, we examine the epidemic's effect on merger and acquisition projects only, as noted in the Nocke and Yeaple (2007), a large fraction of FDI flows are due to cross-border mergers and acquisitions. Following Baker et al. (2009), we use the M&A data from the SDC platinum. The SDC sample, which covers years from 1978 to 2018, reports transaction-level information on M&A projects, including the acquirer and target firms, their countries, the transaction value and the date. To be consistent with our baseline setting, we chose a sample from the 2001–2012 period. We further cleaned the data by following procedures in Nguyen and Phan (2017):

1. Only M&A that has been completed is included in our sample.
2. Following the definition of FDI proposed by the UNCTAD bilateral investment database, we selected only transactions in which more than 10% of shares of a company were acquired.
3. We excluded LBOs (leveraged buyouts), spinoffs, recapitalisations, self-tender offers, exchange offers, repurchases and privatisations.
4. We excluded firms from the utility (standard industrial classification [SIC] codes 4900–4999) and financial industries (SIC codes 6000–6999) from the analysis.
5. We aggregated all deals to the bilateral-year level and then calculated the annual number of bilateral merger and acquisition projects.[22]

The econometric model is similar to the baseline setting, except that (i) we change the dependent variable to a number of bilateral cross-border M&As, (ii) we run the equation at the bilateral-industry-year level and (iii) we also include industry-year fixed effect.

Table A1 reports the results. The dependent variable is the natural logarithm of a number of M&A projects. The coefficient in column (1) indicates that, during the outbreak, the number of cross-border mergers and acquisitions decreased by 2.742 times on average. Additionally, after the outbreak, the number of cross-border mergers and acquisitions increased by 1.919 times. In the second and third columns, the key explanatory variables are changed from dummy variables to the number of deaths or number of infections as indicators of the seriousness of the epidemic. We also find that the outbreak does not reduce the number of bilateral M&As in the long term, although it does cause significant fluctuations in the number of bilateral M&As.

[22]Because there are many missing values in the M&A data, we use the number of bilateral M&As in our measurements.

TABLE A1 Robustness check: use cross-border M&As data.

	Different measures for epidemic outbreak		
	Dummy	Log (Death)	Log (Affected)
	(1)	(2)	(3)
$Shock\_Period_{jt}$	−2.742***		
	(0.997)		
$Shock\_After_{jt}$	1.919***		
	(0.676)		
$Deaths\_Period_{jt}$		−0.512***	
		(0.180)	
$Deaths\_After_{jt}$		0.337***	
		(0.123)	
$Affected\_Period_{jt}$			−0.263***
			(0.096)
$Affected\_After_{jt}$			0.291***
			(0.089)
Control	Y	Y	Y
Country-pair FE	Y	Y	Y
*Home Country FE*Year FE*	Y	Y	Y
R^2	.931	.931	.931
N	9894	9894	9894

Note: In this table, we replace the original FDI data with cross-border M&A data from SDC platinum. The dependent variable is the log of the number of bilateral cross-border M&As. Column (1) presents results for the effect of epidemic outbreaks on cross-border M&As. Columns (2) and (3) replace the dummy variables with the number of deaths and number of infections, respectively. ***significant at 1% level, **significant at 5% level and *significant at 10% level.

APPENDIX 2: DIFFERENT MOTIVATIONS FOR FDI

The existing literature believes that the motivation of FDI can be roughly divided into two types: (i) the export-oriented FDI or vertical FDI, which refers to the acquisition of resources such as labour in the host country for intermediate goods processing and re-export through foreign direct investment (Driffield & Chiang, 2009; Helpman, 1984; Hines, 1996; Xing, 2006) and (ii) the market-seeking FDI, which refers to foreign investors who invest in expanding their market share in the host countries (Child & Rodrigues, 2005; Rohra & Chawla, 2015). To distinguish which FDI motivation is more susceptible to the impact of the outbreak, we use the number of people with basic education in 2000 to represent the country's labour force advantage and re-export advantage (denoted by Ln*pripop_2000*) and use the GDP growth rate in 2000 to represent country's market advantage (denoted by *Growth_2000*). We then interact these two specific advantages of a country respectively with the baseline measurement of epidemic outbreaks (including variables $Shock\_Period_{jt}$, $Deaths\_Period_{jt}$ and $Affected\_Period_{jt}$).

The results are shown in Table A2. We find that the coefficients of interaction terms between the epidemic outbreak index and the labour advantage are significantly negative, suggesting that the FDI aiming to utilise labour in the host country and re-export is more sensitive to epidemic shocks. Such results could be explained from two aspects. First, labour-seeking FDI involves production and requires the gathering of people. Second, the host country only takes the role of production but not the role of consumption, which means that they can be substituted by other countries. In other words, investors may reallocate the production to other developing countries with cheap and abundant labour if their initial target countries are hit by epidemic outbreaks. On the other hand, the coefficients of interaction terms between the epidemic outbreak index and the market advantage are not significant, suggesting that market-seeking investments are less vulnerable to epidemic outbreaks. This could be explained by the non-substitutability of the promising market in the targeted host countries.

TABLE A2 Heterogeneity of FDI motivation

	Different measures for epidemic outbreak		
	Shock dummy	**Ln (Deaths)**	**Ln (Affected)**
	(1)	**(2)**	**(3)**
*Shock_Period**Lnpripop_2000*	−0.158***	−0.027***	−0.020***
	(0.047)	(0.008)	(0.006)
*Shock_Period*Growth_2000*	−0.038	−0.006	−0.005
	(0.040)	(0.007)	(0.004)
Shock_Period	1.371**	0.228**	0.178***
	(0.589)	(0.104)	(0.064)
Control	Y	Y	Y
Country-pair FE	Y	Y	Y
Home Country FE Year FE*	Y	Y	Y
R^2	.401	.401	.401
N	27,825	27,825	27,825

Note: In this table, we test the heterogeneous effects rising from different FDI motivations. The dependent variable is bilateral FDI flow after IHS transformation. We interact the labour advantage and market advantage of the country successively with the epidemic outbreak index as the independent variable. Column (1) is the result of the interaction term the outbreak dummy variable with the specific advantage of the outbreak country. Columns (2) and (3) replace the dummy variables with the number of deaths and the number of infections, respectively. ***Significant at 1% level, **significant at 5% level and *significant at 10% level.