

CHAPTER 3

What Happens to Productivity During Major Adverse Events

Since 2000, there have been three major global slowdowns, with the latest and most pronounced episode triggered by the COVID-19 pandemic. At the same time, many countries have faced major adverse events including natural disasters, wars, and financial crises, all of which can lead to long-lasting harm to productivity. Wars inflict particularly severe damage to productivity, while financial crises also lead to substantial losses, especially accompanied by a rapid build-up of debt. The greater frequency of natural disasters, especially climate disasters, means that they have the largest aggregate impact on productivity, as the natural disasters have occurred most often and their frequency has doubled since 2000. Global adverse events—such as an epidemiological disaster of the magnitude of the COVID-19 pandemic—can have large sustained negative effects on productivity through a dislocation of labor, a tightening of credit, a disruption of value chains and a decline in innovation. Policies to counter the negative consequences of adverse shocks include accommodative fiscal policies such as reconstruction spending on resilient infrastructure; transparent governance; efficient use of relief funds; as well as growth-friendly structural reforms. Appropriate policies and regulations concerning finance, construction, and environmental protection can help reduce the frequency of adverse shocks.

Introduction

The aftermath of the 2007-09 global financial crisis (GFC) witnessed a broad-based slowdown in labor productivity growth lasting over a decade (Chapter 1). This follows a typical pattern associated with adverse events such as natural disasters, wars and financial crises. These events often result in protracted economic losses through declines in both the level and growth rate of output, as well as persistent losses in labor productivity.^{1,2} Among natural disasters, the COVID-19 pandemic—a major epidemiological disaster—is an adverse event on a massive global scale, and could have a large and persistent impact on global productivity.

The damage from adverse events comes through a variety of channels. Natural disasters and wars may damage key infrastructure and disrupt value chains (Acevedo et al. 2018; Cerra and Saxena 2008). Financial crises increase uncertainty, damage confidence, impede access to finance, and lower corporate earnings—all developments that are likely to reduce investment. More generally, adverse events can dampen labor productivity by

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¹ See Cerra and Saxena (2008); Blanchard, Cerutti, and Summers (2015); Cerra and Saxena (2017); Furceri and Mourougane (2012b); and Ray and Esteban (2017).

² See Jordà, Schularick, and Taylor (2013); and Kilic Celik et al. (forthcoming).

causing a loss of skills, and reducing the efficiency of job matching, as well as by disrupting knowledge creation, transfer, and acquisition. The growth of labor productivity is therefore likely to be impeded by declines in both the growth of total factor productivity (TFP) and capital deepening.³

Severe global biological disasters such as COVID-19 can damage labor productivity by affecting both supply and demand (Chapter 6). Adverse supply-side effects can occur through the depletion of labor force; the tightening of financial conditions; and the disruption of supply chains, which are an important measure for the diffusion of innovation. The COVID-19 pandemic is also weighing sharply on aggregate demand, by depressing consumer demand for goods and services, eroding business confidence and investment, and raising financial costs (Baker et al. 2020; Ludvigson, Ma, and Ng 2020; Ma, Rogers, and Zhou 2020). Weaker aggregate demand can reduce the incentive for product innovation, quality improvement, slow technological progress and lower productivity. Furthermore, these negative impacts can be amplified by other factors such as cross-border spillovers, lingering financial vulnerabilities and the compounding effects of recessions. An analysis of economic developments around previous, smaller-scale epidemiological disasters can provide a framework for understanding the channels through which productivity could be affected by COVID-19, and the potential persistence of its effects (Box 3.1).

The productivity losses that result from adverse events in emerging markets and developing economies (EMDEs) can reduce the rate of convergence to the advanced economy technology frontier (Chapter 4). However, the effects of adverse events on labor productivity and output hinge not only on their magnitude, duration, and frequency, but also on country characteristics and circumstances, including the policy response and the pre-shock buffers established by policy makers. Large-scale and severe disasters are typically more damaging to labor productivity and output. Low-income countries (LICs) and countries that are already affected by fragile and conflict-affected situations (FCS) have generally been less able than other countries to cope with wars and climate disasters such as droughts. If sufficiently severe, natural disaster can trigger financial crises—particularly in countries with high levels of debt—or lead to conflicts and wars.

Policies should be geared toward both reducing the likelihood of adverse shocks and alleviating their impacts. Depending on available policy space, countercyclical macroeconomic policies can help counter negative effects on investment, and labor markets. Successful examples include the fiscal and monetary stimulus undertaken after

³TFP growth captures growth in production not explained by increases in factor inputs (essentially capital and labor). Under a standard growth accounting decomposition, which relies on a number of special assumptions, TFP growth may be computed as a residual of labor productivity growth after deduction of the estimated contribution of the growth of capital per unit of labor (capital deepening). Labor productivity growth is prone to measurement issues, especially in countries where services, the government or informal sectors account for large shares of the economy. Estimates of TFP growth depend additionally on a number of special assumptions, including that factors of production (labor and capital) are paid their marginal products, presumably under conditions of perfect competition and constant returns to scale (See Annex 3.2 and Chapter 1).

the GFC, and the COVID-19 pandemic in 2020 by many advanced economies and EMDEs and the international assistance provided for reconstruction in the aftermath of recent natural disasters in some FCS countries.⁴ Structural policy frameworks—such as the quality of governance and business climates—can facilitate faster adjustment, protect vulnerable groups, and mitigate long-lasting damage to productivity.

This chapter examines a wide range of adverse events to assess the extent to which they have had protracted effects on labor productivity and TFP. The chapter aims to shed light on the following questions:

- How frequently and through what channels have adverse events affected productivity?
- How have adverse events differed in the scale of their impact on productivity?
- What policies can help to mitigate the impact of adverse events on productivity?

Contributions

This chapter makes several contributions to an expanding literature on the impact on productivity of adverse events.

Systematic cross-country evaluation of adverse events on productivity. This chapter is the first to undertake a systematic study of the effects of a broad range of adverse events—natural disasters (with a focus on large epidemics), wars, and financial crises—on alternative productivity measures across a wide range of advanced economies, EMDEs, and LICs.

Comprehensive explorations of persistent effects on productivity. One key aspect of the effects of adverse events on productivity is their persistence. Several studies have documented protracted losses in output or productivity following business cycle downturns, recessions or financial crises.⁵ This chapter builds on and broadens previous work (Kilic Celik et al. forthcoming; Mourougane 2017; Noy 2009; Easterly et al. 1993), by assessing the channels, the magnitude of the losses, and the speed of recovery across a wide range of different types of adverse events.

Comprehensive discussion of supportive policy framework. This chapter analyzes feasible policies to mitigate the corrosive effects of negative shocks. It discusses the role of structural policies and reforms that can support productivity following adverse shocks. It also highlights the importance of fiscal space in building a cushion that can be used to counter productivity loss in a country hit by adverse events.

⁴The effectiveness of such assistance depends on the government's ability to efficiently spend the relief money where it is needed. Designing and deploying a disaster-response infrastructure with well-defined rules and procedures before disasters hit improves resilience and boosts the effectiveness of reconstruction efforts (Hallegatte and Rentschler 2018).

⁵See Hall (2014); Blanchard, Cerutti, and Summers (2015); and Cerra and Saxena (2008).

Main findings

The estimated results, broadly consistent with the literature, include the following:

- *Natural disasters have occurred more often than wars or financial crises and their frequency has increased since 2000.* Natural disasters can be subdivided into several distinct types: climate disasters such as floods and cyclones, biological disasters such as epidemics or insect infestations, and geophysical disasters such as earthquakes and volcanoes. In the period 1960–2018, the number of episodes of natural disasters was 25 times that of wars and 12 times that of financial crises. Climate-related events were the most frequent type of natural disaster, with a doubling of their frequency after 2000. LICs, and particularly sub-Saharan Africa (SSA), were most affected by natural disasters. Biological and geophysical episodes are less frequent and are often more geographically contained.⁶
- *Severe disasters have lasting effects on productivity.* While wars inflict particularly severe and long-lasting damage to both capital and total factor productivity, the high frequency of climate disasters increases their importance as a source of damage to productivity. On average during 1960–2018, climate disasters reduced annual contemporaneous labor productivity by about 0.5 percent—about one-fifth of the impact of a typical war episode. However, climate disasters have occurred 25 times as frequently as wars, meaning their cumulative negative effects on productivity are larger. Moreover, while the frequency of severe natural disasters has stabilized since 2000, they have strong negative effects on productivity. After three years, severe climate disasters lower labor productivity by about 7 percent, mainly through weakened total factor productivity. Severe disasters can also trigger other types of adverse events such as financial crises and wars, thus compounding the corrosive effects on productivity.
- *Severe epidemics such as COVID-19 can cause persistent damage to productivity.* Four epidemics since 2000 (SARS, MERS, Ebola, and Zika) had significant and persistent negative effects on productivity.⁷ They lowered productivity by 4 percent after three years. Amid elevated uncertainty, epidemics have reduced labor productivity through their adverse effects on investment and the labor force. The COVID-19 pandemic may be significantly worse than most past disasters because of its global reach and the unprecedented social distancing and containment measures put in place to slow the spread of the virus.
- *Productivity is highly vulnerable to financial stress, especially when accompanied by a rapid build-up of debt.* Financial crises weigh heavily on productivity growth

⁶Coronavirus epidemic is one of the very rare pandemics which has affected almost every country and region. This might be a signal of future pandemics with increasing international mobility of people (Jordà, Singh, and Taylor 2020).

⁷Swine flu (H1N1, 2009–10) is excluded since it coincided with the 2008–09 global financial crisis.

through a wide range of channels. During debt accumulation episodes associated with financial crises, cumulative productivity gains three years into the episode were 2 percentage points lower than in episodes without crises in EMDEs. The rapid build-up of debt in EMDEs since the GFC increases vulnerabilities to financial crises and limits the ability of countries to cope with other types of adverse events. The current COVID-19 is likely to exacerbate those vulnerabilities by further stretching public and private balance sheets.

- *Appropriate policies can help to prevent and to mitigate the effects of adverse events.* A rapid policy response to adverse events, including countercyclical macroeconomic policies and reconstruction spending when appropriate, can help to mitigate the negative effects on productivity. Improving institutions and the business climate can also help increase the pace of recovery following an adverse event. Appropriate policies and regulations with respect to finance, construction, and environmental protection can help reduce the frequency of adverse events. Fiscal space allows economies to fund recovery efforts after natural disasters, and sound fiscal policies tend to limit the likelihood of a financial crisis. Fiscal stimulus also helps cushion the severity of large adverse events such as severe biological disasters.

The remainder of this chapter is organized as follows. Section 2 reviews the literature and seeks to identify the stylized facts relating to the effects of adverse events and the channels through which natural disasters, wars, and financial crises have affected productivity. Section 3 describes the results of new research into the negative impacts of these adverse events on productivity across different groups of countries. Section 4 discusses the policy options available to counter the corrosive effects of adverse events on productivity. The chapter concludes with a summary of the findings. Box 3.1 focuses on the effects of epidemics on productivity.

Adverse events: Literature and stylized facts

This section reviews the literature on the economic effects of adverse events and documents their main features. It focuses on three main types of adverse events: natural disasters (climate, biological, and geophysical), wars (intra-state and external) and financial crises (banking, debt, and currency). The definitions of the events are provided in Annex 3.1. Globally in the period 1960-2018, countries were far more frequently hit by natural disasters than by financial crises or wars (Figure 3.1). However, the frequency of big and severe natural disasters—defined as causing losses of life exceeding 10 and 100 people per million—stabilized after 2000, perhaps reflecting better mitigation policies in some countries as they have confronted climate change (Figure 3.1).

While a specific type of event can occur many times in a country each year, an episode is defined if the event occurs at least once in a country in a year. Therefore, there are typically more occurrences than episodes. The remainder of this chapter focuses on the impacts of episodes of natural disasters, wars and financial crises. The three broad types of adverse events are now explored in more detail.

Natural disasters

Three types of natural disasters are considered: climate events (such as storms, floods, droughts, and periods of extreme temperature), biological events (such as epidemics and insect infestations), and geophysical events (such as earthquakes and volcanoes). Natural disasters, unlike financial crises, are typically measured in terms of the number of deaths and casualties, the number of people otherwise affected, and property damage.⁸ Natural disasters can affect productivity through various channels:

- *Erosion of human capital.* The human cost of natural disasters can be substantial. They often lead to many fatalities and large population displacements. They also tend to degrade hygiene conditions in affected areas, increase the risk of large-scale outbreaks of infectious diseases and epidemics, and aggravate health challenges. In the case of a global pandemic such as COVID-19, the disruption of labor supply is exacerbated by containment measures that make it difficult for workers to get to their places of employment or work in close physical proximity with each other. Moreover, prolonged natural disasters can disrupt schooling, undermine learning conditions, and erode human capital through degraded work environments, sickness, etc.⁹
- *Destruction and misallocation of physical capital.* Natural disasters can destroy critical physical assets, damage major infrastructures, cut supply lines, and discourage private investment.¹⁰ For the period 2000-12, the annual cost of natural disasters worldwide has been estimated to have been in excess of \$100 billion (Kousky 2014).¹¹ Moreover, major pandemics such as the COVID-19 hinder capital accumulation due to a substantial increase in uncertainty (World Bank 2020d). Natural disasters tend to reduce and degrade the capital stock, and can lead to a misallocation of the residual capital, since undamaged roads or offices (residual capital) often cannot be readily used in the way they had been, or used to replace or repair other damaged assets such as bridges or factories. This misallocation of capital weighs on labor productivity (Hallegatte and Vogt-Schilb 2019).
- *Disruption of innovation.* Beyond the immediate loss of lives and damage to physical assets, natural disasters can lead to delayed or canceled investments in new technologies. The disruption of global value chains can also impede the creation, transfer, and adoption of new technologies (Bloom et al. 2010, ADB 2019). This was exemplified by the containment measures of the COVID-19 that have limited mobility, compressed trade and to some extent restricted the diffusion of

⁸ The number of people affected (excluding those killed) is usually considered to be the sum of people injured, made homeless, and otherwise requiring immediate assistance. Property damage includes damage to crops and livestock as well as real estate (Annex 3.1).

⁹ See Acevedo et al. (2018); IMF (2017); and Thomas and López (2015).

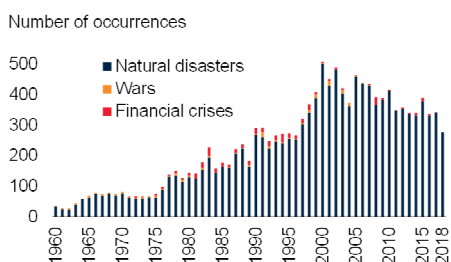
¹⁰ See Kunreuther (2006) and Sawada, Tomoaki, and Bhattacharyay (2011).

¹¹ In assessing the economic cost of a disaster, it is important to avoid double-counting losses: the value of the damaged machine and the subsequent lost production should not both be counted as a loss.

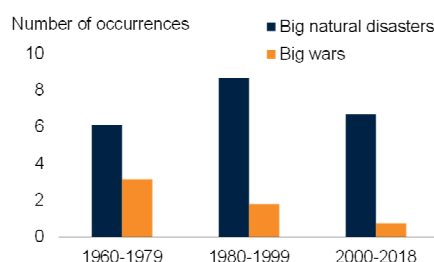
FIGURE 3.1 Global occurrence of major adverse events, 1960-2018

In 1960-2018, countries were hit more frequently by natural disasters than by financial crises or wars. The occurrence of natural disasters per year rose steeply until 2000 and then levelled off; in 2000-18 their average occurrence per year was nearly double that of the preceding 20 years. The occurrences of the big and severe climate disasters stabilized after 2000, perhaps reflecting better mitigation policies. The frequency of financial crises spiked in the 1980s and 1990s, and fell by 70 percent after 2000. The frequency of wars declined by 50 percent in 2000-18 relative to 1980-99.

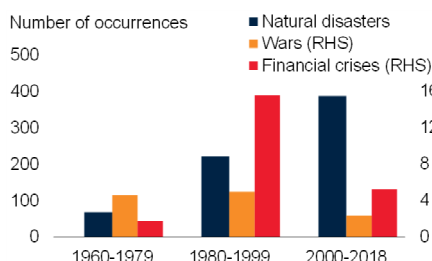
A. Number of occurrences per year



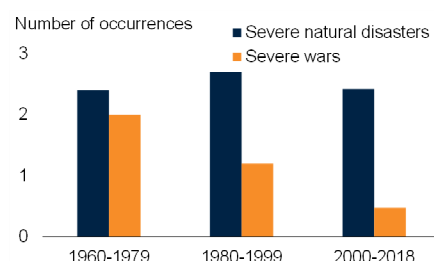
B. Average number of occurrences for big natural disasters and big wars per year



C. Average number of events per year



D. Average number of occurrences for severe natural disasters and severe wars per year



Source: Correlates of War (COW); EM-DAT; Laeven and Valencia (2018); Peace Research Institute Oslo (PRIO); World Bank.

Note: Financial crises include banking crisis, currency crisis, and sovereign debt crisis (Laeven and Valencia 2018). Natural disasters include climate, biological, and geophysical disasters (EM-DAT). Wars include intra-state, extra-state, and inter-state wars (COW and PRIO). Definitions are in Annex 3.1. A specific type of event can have multiple occurrences in a country-year pair. Big natural disasters and big wars are defined as events that led to at least 10 deaths per million population. Severe natural disasters and severe wars are defined as events that led to at least 100 deaths per million population. The sample includes 170 economies: 35 advanced economies and 135 EMDEs, of which 27 are low-income countries.

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innovation. Conversely, effective reconstruction efforts can boost investment and enhance productivity via upgraded capital, health improvements and widespread use of new technologies.¹²

¹²The overall impact of a natural disaster depends partly on initial economic conditions. A disaster may be more economically damaging in periods of high employment and capacity utilization because the increase in output needed for reconstruction may not be feasible, and the increase in demand generated may induce inflation. By contrast, a disaster that occurs when the economy is depressed may cause less economic damage as the stimulus effect of reconstruction will activate unused resources (Benson and Clay 2004; Cuaresma, Hlouskova, and Obersteiner 2008; Hallegatte and Vogt-Schilb 2019; Skidmore and Toya 2002).

TABLE 3.1 Number of episodes by type of events

	AEs	EMDEs	LCs	World
Natural disasters	1031	4699	1098	5730
Climate disasters	843	3054	651	3897
Biological disasters	50	953	369	1003
Geophysical disasters	138	692	78	830
Wars	45	191	55	236
Intra-state wars	0	123	46	123
External wars	45	68	9	113
Financial crises	54	390	83	444
Systemic banking crisis	34	113	27	147
Currency crisis	18	208	44	226
Sovereign debt crisis	2	69	12	71

Note: Natural disasters include climate, biological, and geophysical disasters (EM-DAT). Wars include intra-state and external (extra-state and inter-state) wars (COW and PRIO). Financial crises include banking crisis, currency crisis, and sovereign debt crisis (Leaven and Valencia 2018). Sample is restricted to the observations where labor productivity growth data exist for the period 1960-2018. For each country-year pair, the episode dummy of a specific type of event is 1 if the event occurs at least once (≥ 1), 0 otherwise. The total number of episodes (in bold) for each group of events (all financials, all disasters, all wars) may include events that occur simultaneously. The events are defined in Annex 3.1. AEs = advanced economies, EMDEs = emerging markets and developing economies (including low income countries), LCs = low income countries.

In addition to supply effects, due to the many unknowns, epidemics and pandemics can weigh on productivity through demand-side channels, by raising uncertainty, eroding consumer and business confidence, weakening investment and depressing demand (Box 3.1).

Increase in frequency of climate and other natural disasters. Climate disasters accounted for around 70 percent of natural disasters during 1960-2018, occurring twice as often as biological and geophysical disasters combined (Table 3.1, Figure 3.2). From 1960-79 to 2000-18, there was a large increase in the number of natural disaster episodes.¹³ Increases occurred in all three categories, but most markedly in climate disasters, the frequency of which tripled between 1960-79 and 2000-18.¹⁴ Over 2000-18, natural disasters affected some 200 million people, costing on average more than 60,000 lives each year (Ritchie and Roser 2020). In 2000-18, the average number of climate disaster episodes per year doubled relative to 1980-99, while the frequency of biological and geophysical disaster episodes increased by 40 and 10 percent respectively (Figure 3.2). Also in 2000-18, a natural disaster was 80 percent more likely to occur in LCs, and 35 percent more likely to occur in EMDEs, than in advanced economies.

Pandemics. Global pandemics such as the COVID-19 (2019-20) are rare events. There were only a few pandemics in the 20th century including the Spanish flu (1918-19),

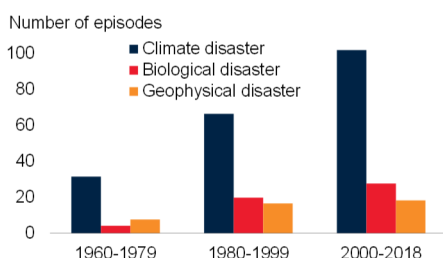
¹³To some degree, the increase in the number of recorded events may reflect improved measurement of natural disasters, particularly for small events.

¹⁴Climate disasters refer to extreme weather events. Exposure to an adverse weather event will depend on the size of the population and total asset value located in at-risk areas. Vulnerabilities materialize when weather events hit exposed populations and assets, leading to economic losses (Cavallo and Noy 2011; Costanza and Farley 2007).

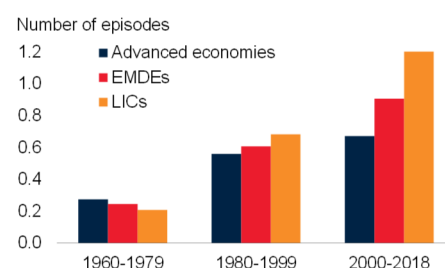
FIGURE 3.2 Episodes of natural disaster

Climate disasters were the most frequent type of natural disaster in the full sample period. The annual frequency of climate-related episodes nearly doubled after 2000, while the frequency of biological and geophysical disaster episodes increased by 40 and 10 percent, respectively. Since 2000, the frequency of big and severe natural disasters has levelled off. After 2000, a natural disaster was 80 percent more likely to occur in an LIC and 35 percent more likely in an EMDE than in an advanced economy. Among EMDE regions, SSA experienced the steepest increase in the frequency of natural disasters after 2000 relative to 1980-99.

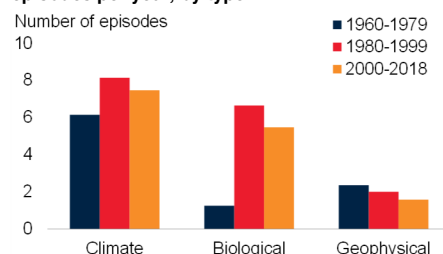
A. Average number of natural disaster episodes per year, by type



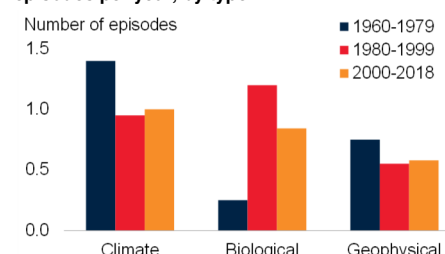
B. Average number of natural disaster episodes per country per year



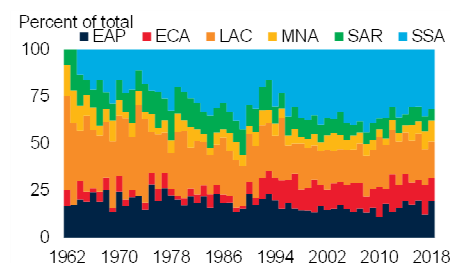
C. Average number of big natural disaster episodes per year, by type



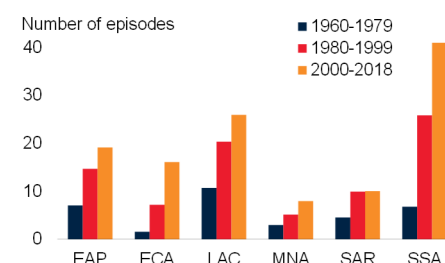
D. Average number of severe natural disaster episodes per year, by type



E. Share of natural disasters, by region



F. Average number of natural disaster episodes per year, by region



Source: EM-DAT; World Bank.

Note: Natural disasters include climate, biological, and geophysical disasters (EM-DAT). An episode dummy for a specific type of event is 1 if the event occurs at least once (≥ 1) in a country-year pair and 0 otherwise. Big natural disasters and big wars are events that led to at least 10 deaths per million population. Severe natural disasters and severe wars are events that led to at least 100 deaths per million population. AEs=advanced economies, EMDEs=emerging market and developing economies (including low income countries), LICs=low income countries. EAP = East Asia and Pacific, ECA = Europe and Central Asia, LAC = Latin America and the Caribbean, MNA = Middle East and North Africa, SAR = South Asia, SSA = Sub-Saharan Africa. The sample includes 170 economies: 35 advanced economies and 135 EMDEs, of which 27 are low-income countries.

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Asian flu (1957-58), Hong Kong flu (1968-69), HIV/AIDS (1980s). Since the 2000s, the major epidemics were SARS (2002-03), swine flu (2009-10), MERS (2012), Ebola (2014-15), Zika (2015-16), which affected over 115 EMDEs and advanced economies (Box 3.1). The COVID-19 (2019-20) outbreak has affected virtually all countries around the world and led to a sudden stop of the global economy.

Regional distribution. SSA seems to be more exposed to natural disasters than other EMDE regions. In both 1980-99 and 2000-18, SSA had the highest frequency of natural disasters among EMDE regions. And in 2000-18, SSA experienced the largest increase in the frequency of natural disaster episodes relative to 1980-99. EAP and LAC were hit by at least 20 natural disaster episodes per year over 2000-18 (Figure 3.3). While climate events were relatively more frequent in East Asia and Pacific (EAP), Latin America and Caribbean (LAC), and SSA, historically, the largest number of biological disasters such as epidemic outbreaks occurred in SSA. The region least frequently affected by natural disasters was Middle East and North Africa (MNA).¹⁵

Exposure to frequent natural disasters is correlated with lower productivity. While the number of natural disaster episodes tripled between 1960-89 and 1990-2018, labor productivity growth halved in advanced economies and slowed in EMDEs other than LICs. Thus, more frequent natural disasters were correlated in this period with weaker labor productivity growth. The annual frequency of natural disasters and TFP growth are also negatively correlated in advanced economies. Moreover, severe natural disasters, especially severe biological disasters, are associated with weaker labor productivity and TFP in EMDEs. Three years into a severe natural disaster episode median labor productivity was around 8 percent lower in the countries affected, and TFP was 7 percent lower than in countries unaffected (Figure 3.3).

Wars

Apart from their direct toll on human life and welfare, wars can have major adverse effects on output and productivity (Abadie and Gardeazabal 2003; Cerra and Saxena 2008). Two types of wars are considered: intra-state and external armed conflicts (which include extra-state and inter-state wars).¹⁶ The destruction, disruption, and diversion effects of wars can cause sharp reductions in the labor force and physical capital, and dampen productive investment and innovation.¹⁷

- *Reduced and disrupted labor forces.* Conflict-related losses of lives, coupled with population displacements, dampen output directly and disrupt the functioning of labor markets (Field 2019; Mueller 2013; Ksoll, Macchiavello, and Morjaria

¹⁵ Regions with large geographical areas can be exposed to more natural disasters than regions with small geographical areas.

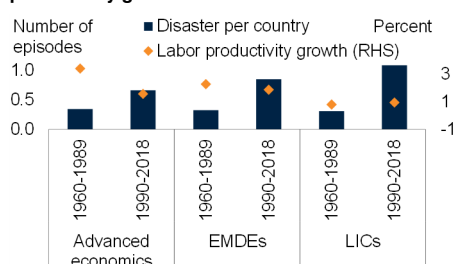
¹⁶ Intra-state wars are conducted between a state and a group within its borders. Extra-state wars take place between a system member and a non-state entity (not a system member). Inter-state wars are conducted between members of the interstate system.

¹⁷ See Becker and Mauro (2006); Collier (1999); Easterly et al. (1993); Field (2008); Raddatz (2007), and Rodrik (1999).

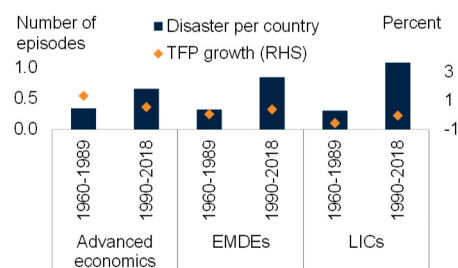
FIGURE 3.3 Correlations between natural disaster frequency and productivity growth

On average comparing 1960-89 with 1990-2018, the number of natural disaster episodes per country per year correlates negatively with labor productivity growth in advanced economies and EMDEs—these correlations are weak for LICs. The correlations between the frequency of these events and TFP growth are negative for advanced economies; but they are mixed for EMDEs and LICs. In EMDEs, severe natural disasters, especially severe biological disasters, are associated with lower labor productivity and TFP.

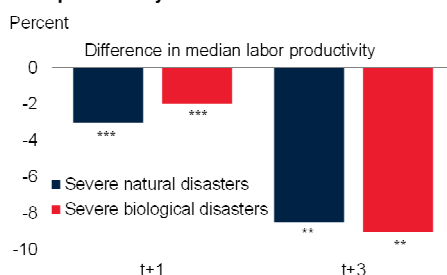
A. Average number of natural disaster episodes per country per year and average labor productivity growth



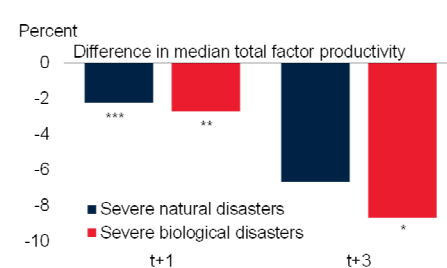
B. Average number of natural disaster episodes per year and average TFP growth



C. Effects of severe natural disaster episodes on labor productivity in EMDEs



D. Effects of severe natural disasters on TFP in EMDEs



Source: EM-DAT; World Bank.

Note: Natural disaster episodes include climate, biological, and geophysical hazards (EM-DAT, Annex 3.1). An episode dummy for a specific type of event is 1 if the event occurs at least once (≥ 1) in a country-year pair and 0 otherwise. Severe natural disasters and severe biological disasters are events that led to at least 100 deaths per million population. EMDEs = emerging markets and developing economies (including low income countries), LICs = low income countries. The sample includes 170 economies: 35 advanced economies and 135 EMDEs, of which 27 are low-income countries.

A.B. Correlations between the average number of natural disaster episodes per country per year and (A) average growth of labor productivity (output per worker), and (B) average growth of TFP over two 30-year periods (1960-1989 and 1990-2018).

C.D. ***, **, and * indicates 1, 5, and 10 percent significance levels.

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2010).¹⁸ Worldwide, about 68.5 million people—or 1 percent of the world's population—were in forcibly displaced situations in 2017 due to conflicts.¹⁹ Moreover, many displaced persons are relatively well educated and skilled.

¹⁸ For instance, during the 2007 post-election violence in Kenya, the labor force in the affected areas was reduced by as much as half owing to deaths, injuries, and lack of security for workers, and as a result wages rose by 70 percent (Ksoll, Macchiavello, and Morjaria 2010).

¹⁹ United Nations High Commissioner for Refugees (2018).

BOX 3.1 How do epidemics affect productivity?

Epidemics that occurred since 2000 are estimated to have lowered labor productivity by a cumulative 4 percent after three years, mainly through their adverse impact on investment and the labor force. Given its global nature, COVID-19 may lead to sizeable adverse cross-border spillovers and weaken global value chains, which will further damage productivity. The immediate policy focus is to address the health crisis but policymakers also need to introduce reforms to rekindle productivity growth once the health crisis abates.

Introduction

Prior to the emergence of COVID-19, there were already concerns about the prospects for long-term productivity growth in emerging market and developing economies (EMDEs) and the achievement of development goals, especially the reduction of poverty. COVID-19 has put these goals in even greater jeopardy (World Bank 2020a). In less than half a year since its start, COVID-19 already ranks as a major disaster (Figure 3.1.1). Since pandemics are rare events, this box sheds light on the effects of COVID-19 on labor productivity by examining epidemics since 1960.

Natural disasters such as biological, climate, and geophysical events have caused significant economic damage.¹ Past severe disasters (more than 100 deaths per million people) are relevant for gauging the likely effects of COVID-19 on labor productivity and understanding the channels through which disasters may affect the economy. The box examines three questions:

- What are the main channels through which epidemics and pandemics affect productivity?
- What are the frequency and extent of epidemics and pandemics?
- What are the likely implications of epidemics and pandemics for productivity?

Channels through which severe epidemics affect productivity

Epidemics and pandemics can affect productivity and long-term economic growth through both supply- and demand-side channels.

Epidemics and pandemics can impact **supply** through:

Note: This box was prepared by Alistair Dieppe, Sinem Kilic Celik, and Cedric Okou, with research assistance by Yi Li, Kaltrina Temaj, and Xinyue Wang.

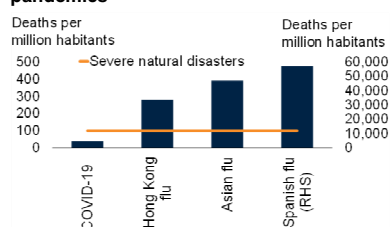
¹ Natural disasters include climate (floods, cyclones), biological (epidemics, insect infestation), and geophysical disasters (earthquakes, volcanoes), and follow EM-DAT definitions.

BOX 3.1 How do epidemics affect productivity? (continued)

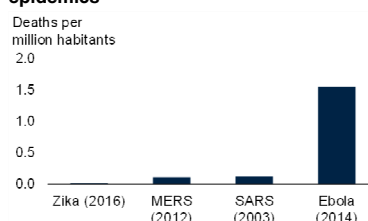
FIGURE 3.1.1 Severity of pandemics, epidemics, and climate disasters

COVID-19 already ranks as a major disaster. In the most severely affected countries, its impact may be as large as those from a severe climate disaster. Climate disasters were the most frequent type of natural disaster in 1960-2018, accounting for nearly 70 percent of all disasters. Epidemics and wars are much rarer but longer-lived. About 20 percent of biological disasters that have affected EMDEs and LICs have been severe.

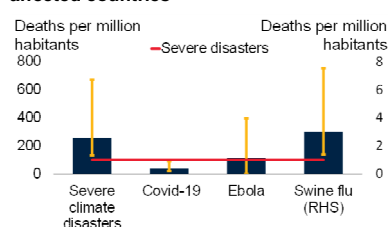
A. Global mortality rates for selected pandemics



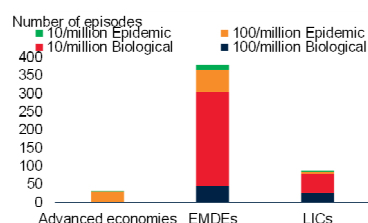
B. Global mortality rates for recent epidemics



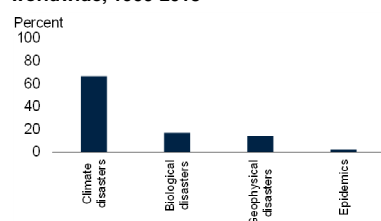
C. Mortality rates for severe climate events, pandemics and epidemics for affected countries



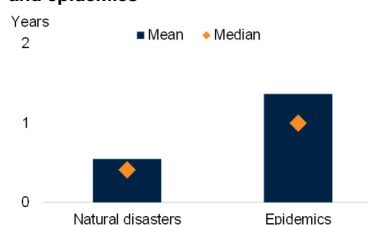
D. Number of biological and epidemic episodes, 1960-2018



E. Episodes by type of natural disasters, worldwide, 1960-2018



F. Average duration of natural disasters and epidemics



Source: Centers for Disease Control and Prevention; EM-DAT; Johns Hopkins University; OurWorldInData.org; United Nations; World Bank; World Health Organization.

A.-B. Cumulative deaths per million population worldwide. Last observation of death toll for COVID-19 is May 14, 2020. Severe climate disasters are defined as events that led to at least 100 deaths per million population.

C. Blue bars indicate the medians of mortality rates across affected countries. The bottom (top) of the yellow line represents the 1st (3rd) quintile. Red marker indicates 100 deaths per million inhabitants.

D.-F. Natural disasters include climate (floods, cyclones), biological (epidemics, insect infestation), and geophysical (earthquakes, volcanoes) disasters, and follow EM-DAT definitions. The sample includes 170 economies: 35 advanced economies and 135 EMDEs, of which 27 are low-income countries.

E. Biological disasters include epidemics.

F. The five pandemics and epidemics considered are SARS (2002-03), MERS (2012), Swine flu (2009), Ebola (2014-15), and Zika (2015-16).

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BOX 3.1 How do epidemics affect productivity? (continued)

- *Depleted labor forces.* Major epidemics can reduce the labor supply by causing widespread sickness and fatalities. Mitigation efforts such as workplace closures, social distancing, and lockdowns to contain the spread of infectious diseases can also disrupt the functioning of labor markets. These disruptions undermine the productivity of those remaining in the workforce owing to the loss of complementary skills, etc.²
- *Weakened physical capital.* Severe epidemics typically damage the outlook for economic activity and profitability due to heightened uncertainty. This epidemic-driven uncertainty can lead to idle physical capital, tighten credit conditions and trigger capital outflows—especially in EMDEs. These effects are likely to hold back capital accumulation.³
- *Disrupted supply chains and innovation.* Major epidemics can freeze and damage global value chains.⁴ They also undermine the incentives to invest in R&D and new technologies, including by weakening property rights and increasing costs of doing business. Capital outflows tend to be associated with drops in inward foreign direct investment, which can be an important source of technology transfer.⁵ Containment efforts during epidemics—such as workplace closures and quarantines—can further limit the diffusion of technologies.

Epidemics and pandemics can impact **demand** through:

- *Lower business investment.* Short-term projections of demand and economic activity tend to be scaled back and business uncertainty tends to increase sharply following major epidemics. These typically cause a sharp drop in investment demand, which can be amplified by the disruption to value chains. The duration of the disaster is essential to its impact on the economy via its effect on investment. A more prolonged epidemic, even at the same magnitude, results in higher uncertainty. This causes firms to delay or deter investments and thereby compounding the negative economic effects of disasters (Bloom 2014; Bloom et al. 2018; Baker, Bloom, and Terry 2019).

²Unexpected adverse events that affect large geographic areas have been shown to have lasting consequences on human capital (health, education, and nutrition outcomes) regardless of the income group. See Acevedo et al. (2018); Akbulut-Yuksel (2009); Alderman, Hoddinott, and Kinsey (2006); IMF (2017); Maccini and Yang (2009); and Thomas and López (2015). Biological epidemics can also disproportionately affect low-skilled workers and raise inequality (Furceri et al. 2020).

³See Collier (1999); Claessens et al. (1997); Claessens and Kose (2017, 2018); and Hutchinson and Margo (2006).

⁴See Collier (1999); Reynaerts and Vanschoonbeek (2018); and Rodrik (1999).

⁵The COVID-19 pandemic is projected to lower foreign direct investment by -20 percent in EMDEs during 2020-21 (UNCTAD 2020).

BOX 3.1 How do epidemics affect productivity? (continued)

The more severe the epidemic, the larger the uncertainty (Ludvigson, Ma, and Ng 2020). Model-based estimates by Baker, Bloom, and Davis (2020) suggest that increased uncertainty accounts for half of the output loss in the U.S. economy in early 2020.

- *Weaker consumer demand.* Job losses, reduced income, increased cost of debt service, higher uncertainty, the forced closure of marketing outlets, and, in the case of diseases, fear of infection, all tend to cause consumers to reduce their spending on goods and services and to increase saving rates. Furthermore, effects on consumer behavior could be long-lasting—for example, a pandemic could cause households to reduce their demand, over an extended period, for travel, tourism, eating out, entertainment, and other activities involving human interaction, and to increase their saving in the absence of close substitutes.

Frequency and short-term effects of disasters

Pandemics and epidemics are rare events although they last longer than other types of disasters. Other biological disasters (such as insect infestation) and geophysical disasters are more common. Climate disasters (such as storms, floods, droughts, and periods of extreme temperature) occur more often but typically last for less than 6 months. All these events are associated with weaker productivity over long time spans.

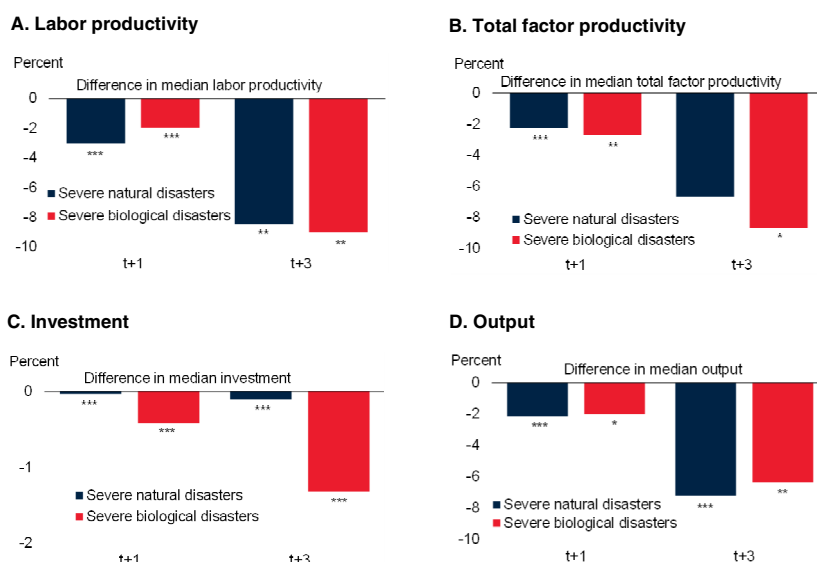
Pandemics. The Spanish flu (1918-19) has an unusually high death toll and mortality rate, killing between 20-100 million people globally. Other, more recent, pandemics had far lower mortality rates. They included the Hong Kong flu (1968-69) and the Asian flu (1957-58), with nearly 300 and 400 deaths per million, respectively. This was followed by swine flu (2009-10), with 11 deaths per million globally (Figure 3.1.1). COVID-19 is the most severe pandemic since the Hong-Kong flu, despite the unprecedented mitigation efforts that have been implemented.

Epidemics since the 2000s. During 2000-18, the world experienced SARS (2002-03), MERS (2012), Ebola (2014-15), and Zika (2015-16). The increased frequency of epidemics increases the likelihood that pandemics will break out. There were over 250 episodes of biological disasters with losses of life of over 10 per million population in the countries affected since 1960. LICs have been disproportionately affected by these types of disasters whereas advanced economies were not affected. The frequency of such biological episodes has been increasing over time, but they have mostly been contained in size and severity. Furthermore, climate disasters tend to be short-lived compared to epidemics which on average last twice as long.

BOX 3.1 How do epidemics affect productivity? (continued)

FIGURE 3.1.2 Severe disasters and productivity

In EMDEs, severe natural disasters, especially severe biological disasters, are associated with lower labor productivity. Severe biological disasters are also correlated with lower investment, possibly reflecting a sizable increase in uncertainty that holds off new spending.



Source: EM-DAT; World Bank

A-D. Natural disasters include climate (floods, cyclones), biological (epidemics, insect infestation), and geophysical (earthquakes, volcanoes) disasters, and follow EM-DAT definitions. An episode dummy for a specific type of event is 1 if the event occurs at least once (≥ 1) in a country-year pair and 0 otherwise. Severe natural disasters and severe biological disasters are defined as events that led to at least 100 deaths per million population. The sample includes 170 economies: 35 advanced economies and 135 EMDEs, of which 27 are low-income countries.

Bars show the difference between the median growth of macroeconomic indicators in EMDEs with and without severe biological disasters (red) and severe natural disasters (blue; including climate, biological, geophysical disasters). A Fisher's test is used to test if medians in two subsamples (with and without disasters) are equal. The four biological disasters considered are SARS (2002-03), MERS (2012), Ebola (2014-15), and Zika (2015-16). Swine flu (2009), which coincided with the 2008-09 global financial crisis, is excluded to limit possible confounding effects. ***, **, and * indicates 1, 5, and 10 percent significance levels.

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Damaging severe disasters. With a rising death toll and possible subsequent infection waves, the COVID-19 pandemic is potentially a severe biological disaster. Compared to unaffected countries, severe biological disasters are associated with 9 percent lower median labor productivity and 8 percent lower total factor productivity (TFP) three years after the shock (Figure 3.1.2). Severe natural disasters (including climate and biological disasters) also correlate with weaker labor productivity and TFP compared to countries not suffering such disasters. In EMDEs, three years into a severe natural disaster episode median

BOX 3.1 How do epidemics affect productivity? (*continued*)

labor productivity was around 8 percent lower in the countries affected, and TFP was 7 percent lower than in countries unaffected whereas investment remained virtually unchanged which could reflect large-scale reconstruction investment offsetting other negative effects.

Investment effects. Median investment growth remained virtually the same in both affected and unaffected countries in natural disasters. This could suggest that large-scale reconstruction investment after a natural disaster roughly offset declines in investment in other activities due to uncertainty. Whereas for severe biological disasters the effects on investment are negative, reflecting the longer duration of the disaster and increased uncertainty.

Long-term effects of epidemics

To help draw inferences on the possible effects of COVID-19, this section examines the extent to which epidemics have lasting negative effects on labor productivity. Epidemics are particularly damaging to productivity, lowering it by 4 percent after three years.

Methodology. The local projection method (LPM) is used to provide a reduced-form estimate of the response of labor productivity to adverse events over various horizons (Jordà, 2005; Jordà, Schularick, and Taylor, 2013; Annex 3.3). It allows to identify key transmission channels through output, investment, and TFP.

Adverse effects of epidemics. Results suggest that four epidemics since 2000 (SARS, MERS, Ebola, and Zika) had significant and persistent negative effects on productivity (swine flu is excluded since it coincided with the global financial crisis).⁶ These estimates indicate that epidemics led, on average, to a contemporaneous loss of productivity equal to about 1 percent (Figure 3.1.3). After three years, such epidemics lowered labor productivity by a cumulative amount of about 4 percent. Over the same horizon, investment declined by nearly 9 percent reflecting heightened uncertainty and risk aversion.

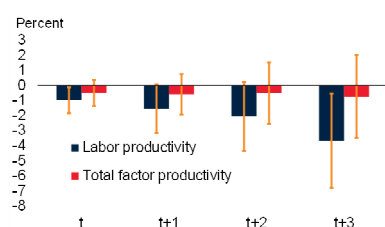
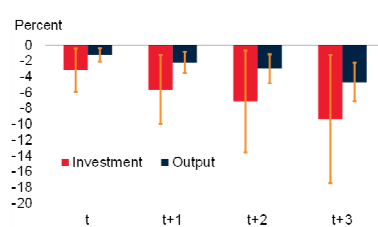
Conclusion

The COVID-19 pandemic raises questions about its effects on productivity. Pandemics and epidemics are rare events in comparison to climate disasters but they have had adverse and persistent effects on productivity. Adverse impacts on

⁶Jordà, Singh, and Taylor (2020) consider major pandemics and find long lasting effects on output. Barro and Ursúa (2008) report that the macroeconomic impact of the Great Influenza Pandemic of 1918 is substantial. Sustained low levels of demand, and excess capacity during disasters, including pandemics, can have persistent effects on productivity (Dieppe, Francis, and Kindberg-Hanlon, forthcoming). Ma, Rogers, and Zhou (2020), also focusing on of the same set of epidemics in 210 countries, find that real GDP in EMDEs is around 2 percent lower on average in the first year decreasing to 4 percent below after five years.

BOX 3.1 How do epidemics affect productivity? (continued)**FIGURE 3.1.3 Impact of epidemics**

SARS, MERS, Ebola, and Zika left lasting scars on labor productivity with declines of around 4 percent after three years and larger effects on investment, whereas estimates suggest that total factor productivity hardly declined. The impact of swine flu too was probably large, but impossible to assess because the epidemic overlapped with the 2008-09 global financial crisis.

A. Effects of epidemics on labor productivity and TFP**B. Effects of epidemics on investment and output**

Source: EM-DAT; World Bank.

Note: Orange lines display the range of the estimates with 90 percentile significance. An episode dummy for a specific type of event is 1 if the event occurs at least once (≥ 1) in a country-year pair and 0 otherwise.

A.B. Bars show the estimated impacts of the four most severe biological epidemics on output, labor productivity, total factor productivity, and investment levels relative to non-affected EMDEs. The four epidemics considered are SARS (2002-03), MERS (2012), Ebola (2014-15), Zika (2015-16). Swine flu (2009), which coincided with the 2008-09 global financial crisis, is excluded to limit possible confounding effects. The sample includes 116 economies: 30 advanced economies, and 86 EMDEs.

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productivity increase more than proportionately with the severity and duration of these types of disasters. Epidemics that occurred since 2000 have lowered labor productivity by a cumulative 4 percent after three years, due to elevated uncertainty and mainly through their adverse effects on investment and the labor force.

The COVID-19 pandemic may have a significantly worse impact on productivity than most previous natural disasters for three reasons:

- *Global reach.* The COVID-19 pandemic appears to have considerably broader reach—in terms of numbers of both countries and people affected—than other disasters since 1960 (Hassan et al. 2020). The increased integration of the global economy, through trade and financial linkages will amplify the adverse impact of COVID-19.
- *Contagion prevention and physical distancing.* As long as strict social distancing is required, some activities will not be viable. In the hospitality sector, where close socialization is part of the product, the capital stock will become

BOX 3.1 How do epidemics affect productivity? (*continued*)

obsolete. Even in less directly affected sectors, severe capacity under-utilization lowers TFP while restrictions to stem the spread of the pandemic remain in place. Disruptions to employment, schooling and other education while restrictions remain in place—or, in the event of severe income losses, even once restrictions are lifted—will also lower human capital and labor productivity (World Bank 2020b).

- *Compounding financial stress.* Financial crises tend to result in especially protracted labor productivity losses (World Bank 2020c).⁷ Larger disasters are more likely to cause a cascade of business and household bankruptcies and hence a systemic financial crisis. Whilst only a few disasters have been associated with financial crises, governments and private sectors entered the COVID-19 pandemic with already-stretched debt burdens (Kose et al. 2020). These have since increased further and heighten risk of a financial crisis should financial conditions tighten further (Ludvigson, Ma, and Ng 2020).

Mitigating factors. In some dimensions, pandemics and epidemics can accelerate productivity-enhancing changes. They can encourage investment in new and more technologically advanced capital and to train more highly skilled workers (Bloom 2014). They may also lead to new opportunities for green growth with environmentally friendly new investment, especially if it is induced by structural reforms (Strand and Toman 2010). The mitigation measures of COVID-19, including social distancing, may encourage investment in more efficient business practices, including robotics and other digital technologies such as artificial intelligence.⁸

Structural reforms. The negative outlook ahead means that, after addressing the immediate health crisis, countries need to make productivity-enhancing reforms a priority. These include facilitating investment in human and physical capital, as well as in research and development; encouraging reallocation of resources toward more productive sectors; fostering technology adoption and innovation; and promoting a growth-friendly macroeconomic and institutional environment (World Bank 2020c). In addition, raising the quality and effectiveness of

⁷ See Benson and Clay (2004); Blanchard, Cerutti, and Summers (2015); Celiku and Kraay (2017); and Cerra and Saxena (2008, 2017). During 1990–2018, the number of financial crises—sovereign debt, banking, and currency—nearly doubled compared to 1960–1989. Over the past three decades, labor productivity growth halved in advanced economies and slowed, albeit less markedly, in EMDEs.

⁸ See Hallward-Driemeier and Nayyar (2017); Hsiang (2010); Skidmore and Toya (2002); and Strobl (2011). The accompanying job losses are likely to be lower-skilled and less productive (Lazear, Shaw, and Stanton 2013). To the extent vulnerable groups are particularly exposed to economic losses from disasters, policies to protect these groups are needed (OECD 2020).

BOX 3.1 How do epidemics affect productivity? (continued)

governance and improving the business climate can encourage a faster rebound from disasters. Governments that improved labor and product market flexibility, strengthened legal systems and property rights, fostered effective competition, and addressed inequality set the foundations for more effective adjustment to adverse events (Anbarci, Escaleras, and Register 2005).

- *Weakened capital deepening.* Violent conflict destroys physical assets, holds back productive investment, provokes capital flight, and causes capital and finance to be diverted to less productive uses, including expenditure on armaments (Collier 1999; Hutchinson and Margo 2006). In the 1980s, wars have been estimated to have lowered the ratio of investment to GDP in Eastern Europe by about 5 percent over 1986-90 (Knight, Loayza, and Villanueva 1996).
- *Hindered innovation.* Wars can have adverse effects on innovation and the adoption of technology.²⁰ They can lead to large-scale institutional disfunction, weakening of property rights, and sharp reductions in R&D investment, and they can also impede global value chains. All these effects can slow technological progress.²¹ Wars can be particularly pernicious in LICs and FCV countries, partly because of their weak R&D capacity.

Intra-state wars in EMDEs, external wars in advanced economies. Between 1980-99 and 2000-18, the number of intra-state and external wars fell by almost 70 percent and 25 percent, respectively (Figure 3.4). EMDEs and LICs were mainly hit by intra-state conflicts, whereas advanced economies mainly experienced external wars (Table 3.1). A typical LIC was twice as likely to experience any kind of conflict as a typical EMDE. In 2000-18, the frequency of wars dropped in all regions. In 1960-2018, intra-state armed conflicts mainly occurred in SSA, whereas external wars mainly occurred in EAP and MNA.

Wars in advanced economies have been accompanied by weaker productivity growth. In advanced economies, the number of wars tripled while labor productivity and TFP growth halved from 1960-1989 to 1990-2018. These associations appear weak in EMDEs and LICs (Figure 3.5).

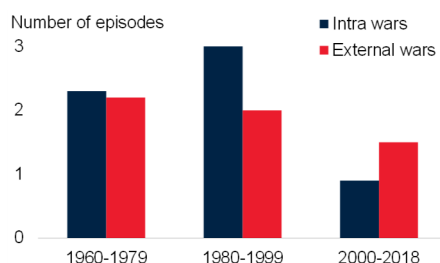
²⁰ In some cases, such as the Manhattan project undertaken during World War II, conflicts can stimulate innovation and R&D.

²¹ See Collier (1999); Rodrik (1999); and Reynaerts and Vanschoonbeek (2018).

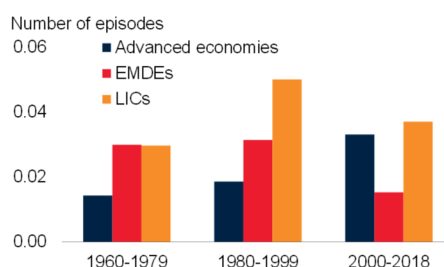
FIGURE 3.4 Episodes of war

Intra-state conflicts were the most frequent type of wars over the full sample. The frequency of war episodes in total dropped after 2000. Since 2000, there were almost 70 percent fewer intra-state and 25 percent fewer external (extra- and inter-state) war episodes per year compared to the 1980s and 1990s. A typical LIC was twice as likely to be hit by a war as a typical EMDE (including LICs) and 10 percent more likely than an advanced economy after 2000. Intra-state conflicts mainly occurred in SSA, whereas external wars mainly occurred in EAP and MNA. The frequency of wars dropped in all regions in 2000-18 relative to 1980-99.

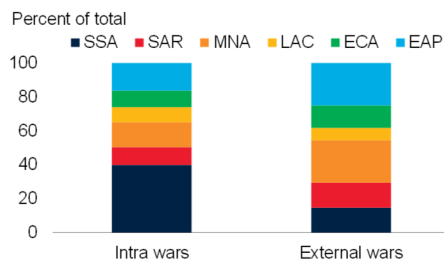
A. Average number of war episodes per year, by type



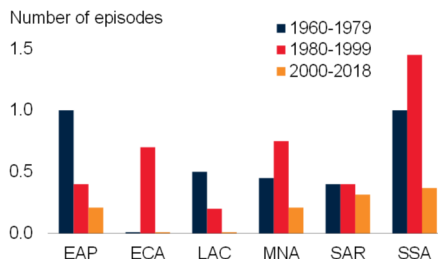
B. Average number of war episodes per country per year



C. Share of war episodes, by region, 1960-2018



D. Average number of war episodes per year, by region



Source: Correlates of War (COW); Peace Research Institute Oslo (PRIO); World Bank.

Note: Wars include intra-state and external (inter-state and extra-state) wars (COW and PRIO, Annex 3.1). An episode dummy for a specific type of event is 1 if the event occurs at least once (≥ 1) in a country-year pair and 0 otherwise. EMDEs = emerging market and developing economies (including low income countries), LICs = low income countries. EAP = East Asia and Pacific, ECA = Europe and Central Asia, LAC = Latin America and the Caribbean, MNA = Middle East and North Africa, SAR = South Asia, SSA = Sub-Saharan Africa. The sample includes 170 economies: 35 advanced economies and 135 EMDEs, of which 27 are low-income countries.

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Financial crises

Financial crises sharply raise borrowing costs and worsen balance sheets. They have often led to severe economic contractions, with lasting corrosive effects on productivity levels and, in some cases, productivity growth.²² In the years since the global financial crisis and subsequent global recession of 2007-09, a broad range of countries has experienced significant and sustained slowdowns of productivity growth (Kose et al. 2020). Financial

²² See Blanchard, Cerutti, and Summers (2015) and Cerra and Saxena (2008, 2017).

crises have often originated from the excessive accumulation of public or private sector debt and the associated development of mismatches in balance sheets. Debt accumulation increases risks to productivity growth not only by increasing the risk of crises in the short term, but also by tending to lead to the misallocation of resources towards low productivity sectors and depressing investment and technological innovation in the long term.²³

Three broad types of financial crises are considered: sovereign debt crises, banking crises, and currency crises (Annex 3.1). This section emphasizes the role of government debt accumulation, financial crises, and productivity losses, because of concerns about elevated debt levels in many countries.

Sovereign debt crises. These can be particularly detrimental to output and productivity. They generally originate from the excessive accumulation of government debt. Before a crisis occurs, higher government debt tends to increase the burden of interest payments in the government budget, and to raise borrowing costs, which may crowd out private investment (Kose et al. 2020; Oulton and Sebastián-Barriel 2017; Reinhart and Rogoff 2010). Excessive growth of government debt erodes the country's ability to borrow, degrades private as well as public creditworthiness, and often leads to a curtailment of credit from institutional investors (Aguilar and Gopinath 2006; Arellano 2008; Sandri 2015). Elevated government debt can affect productivity growth via several channels:

- *Increased probability of financial crises.* Rising government debt will increase the risk of a financial crisis when it raises doubts about its sustainability. One of the ways this may occur is that higher debt may lead governments to adopt lower-cost but higher-risk debt management practices, including issuing debt with shorter maturities or denominated in foreign currency.²⁴ Such practices can sharply raise risk premia on government debt, increasing borrowing costs and the risk of crisis.²⁵ Moreover, high sovereign debt constrains the ability of governments to exercise counter-cyclical fiscal policy.²⁶ Given the close interconnectedness between sovereign, banking, and foreign exchange sectors, sovereign debt crises can precipitate (or be caused by) banking and currency crises, compounding the damage to output and productivity.²⁷
- *Misallocation of resources.* If used to fund productive investments with high rates of return, debt can have positive effects on productivity and growth.²⁸ However, debt accumulation can impede productivity if it is associated with a misallocation of

²³ See Blanchard and Wolfers (2000); Bulow and Rogoff (1989); Hall (2014); and Schnitzer (2002).

²⁴ See Kalemli-Özcan, Laeven, and Moreno (2018).

²⁵ See Aguilar and Gopinath (2006); Arellano (2008); and Sandri (2015).

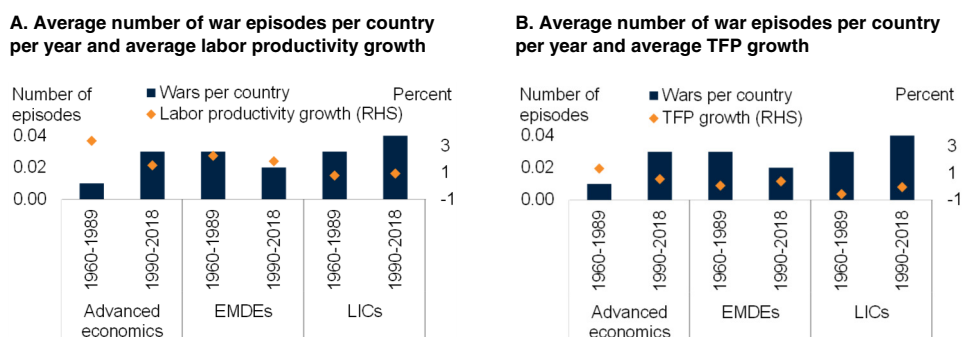
²⁶ See Eberhardt and Presbitero (2015) and Reinhart and Rogoff (2010).

²⁷ See Aghion, Bacchetta, and Banerjee (2000); Aghion et al. (2009); Kalemli-Özcan, Laeven, and Moreno (2018); and Morris and Shin (1998).

²⁸ See Poirson, Pattillo, and Ricci (2004) and Reinhart and Rogoff (2010).

FIGURE 3.5 Correlations between war frequency and productivity growth

In advanced economies, an increased annual frequency of wars from 1960-89 to 1990-2018 was accompanied by lower labor productivity growth; corresponding correlations seem weak for EMDEs and LICs. The correlations between the frequency of war episodes and TFP growth appear negative for advanced economies and EMDEs; but they are mixed for LICs.



Source: Correlates of War (COW); Peace Research Institute Oslo (PRIO); World Bank.

Note: War episodes include intra-state, inter-state and extra-state armed conflicts (COW and PRIO, Annex 3.1). An episode dummy for a specific type of event is 1 if the event occurs at least once (≥ 1) in a country-year pair and 0 otherwise. EMDEs = emerging markets and developing economies (including low income countries), LICs = low income countries. The sample includes 170 economies: 35 advanced economies and 135 EMDEs, of which 27 are low-income countries.

A.B. Correlations between the average number of war episodes per country per year and (A) average growth of labor productivity (output per worker), and (B) average growth of TFP over two 30-year periods (1960-1989 and 1990-2018).

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resources towards projects that yield only short-term returns or purely political gains.²⁹ Such misallocation is more likely if projects are being funded on unrealistic, possibly politically biased, expectations of rapid future growth (Claessens et al. 1997; Claessens and Kose 2017, 2018).

- *Policy uncertainty.* High government debt can increase uncertainty about prospects for economic growth (Kose et al. 2020). For investors, the fear may be that high debt could eventually compel the government to hike taxes (including taxes on future investment returns), curtail growth-enhancing spending, crowd out productive investment (debt overhangs), or delay reforms that could support innovation and productivity growth (IMF 2018; Kumar and Woo 2010).³⁰
- *Productivity losses during rapid debt accumulation episodes.* Long-term productivity gains during rapid debt accumulation episodes have been considerably lower when these debt accumulation episodes were accompanied by financial crises. In a debt

²⁹ See Checherita-Westphal and Rother (2012) and Poirson, Pattillo, and Ricci (2002).

³⁰ With regard to private sector debt, at the firm level, a large outstanding debt stock can weigh on investment and, hence, the productivity that technology embedded in this investment can generate (Bulow and Rogoff 1989; Ridder 2017; Borensztein and Ye 2018). At the government level, debt service on high debt may crowd out other productivity-enhancing spending, including for education, health or infrastructure (Kose and Ohnsorge 2019).

accumulation episode preceding a crisis, the cumulative growth rate of median productivity three years into the episode was 3 percent (Figure 3.6). This is statistically significantly less than the median increase during a debt accumulation episode that was not associated with a crisis (5 percent). The difference may be interpreted as a measure of the short-term damage to productivity from financial crises.

Banking and currency crises. Other types of financial crises, including systemic banking crises and currency crises, can also do lasting damage to productivity.³¹ The disruptions to financial intermediation that occur in banking crises impede investment, curb the funding of productivity-enhancing technologies and typically trigger recessions (Ridder 2017). In periods of protracted economic weakness, prolonged and elevated unemployment erodes human capital.³² Because of their shorter duration, currency crises are typically less harmful to productivity than other financial crises (Cerra and Saxena 2008).

Frequent financial crises erode productivity. Compared to 1960-1989, the number of financial crises episodes nearly doubled in 1990-2018, while labor productivity growth halved in advanced economies and slowed, albeit less markedly, in EMDEs (Figure 3.7). This negative correlation is also observed between the annual frequency of financial crises and TFP growth.

Comparing across types of adverse event

Climate disasters are the most frequent. Globally, natural disasters accounted for more than 90 percent of the recorded adverse events in 1960-2018 (Table 3.1). Over this entire sample, natural disaster episodes were about 25 times more frequent than wars despite the decline in natural disasters over the last ten years (Figures 3.1, 3.8). Financial crises occurred twice as frequently as wars. Severe natural disasters—that caused at least 100 death in a million population—occurred twice as often as severe wars (Figure 3.8). Epidemics and pandemics are rare events.

Wars are typically protracted. The average duration of wars was almost six years. Nearly half of financial crises last for more than two years. Natural disasters are typically much more short-lived (Figure 3.8). Some climate disasters last for just a few days while others, such as droughts, can last for several months. The cumulative loss of productivity can be larger if the adverse events last for a more extended period of time or if reconstruction efforts are delayed (Sawada 2007; Cerra and Saxena 2008).³³

³¹ See Blanchard, Cerutti, and Summers (2015); Cerra and Saxena (2008, 2017); and Oulton and Sebastián-Barriel (2017).

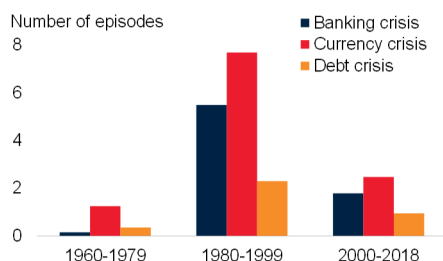
³² See Ball (2009); Blanchard and Wolfers (2000); Bustos et al. (2016); Furceri and Mourougane (2012a); and Hall (2014).

³³ Reconstruction pace may be slowed by financial, physical and transaction constraints (Hallegatte and Rentschler 2018).

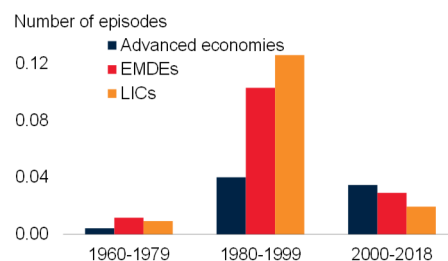
FIGURE 3.6 Episodes of financial crisis

The frequency of financial crises spiked in the 1980s and 1990s. In 2000-18, there were on average six financial crisis episodes a year. Financial crises were markedly more likely to occur in a typical EMDE or LIC than in a typical advanced economy in 1980-99; their frequency declined in EMDEs and LICs after 2000. In 2000-18, ECA, LAC and SSA were more frequently hit by financial crises than other EMDE regions. About 40 percent of episodes of rapid accumulation of total (government and private) debt were associated with financial crises. During those episodes, productivity gains were significantly lower than during other episodes.

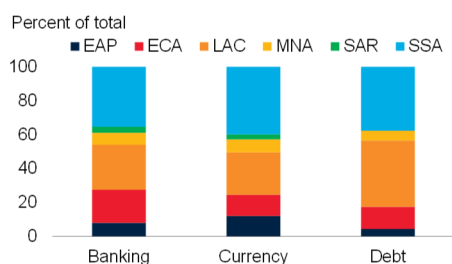
A. Average number of financial crisis episodes per year, by type (World)



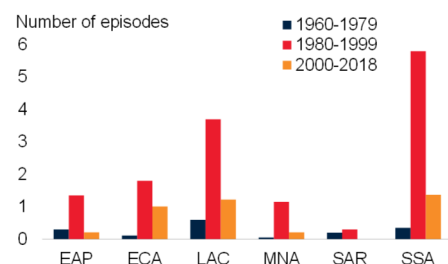
B. Average number of financial crisis episodes per country per year



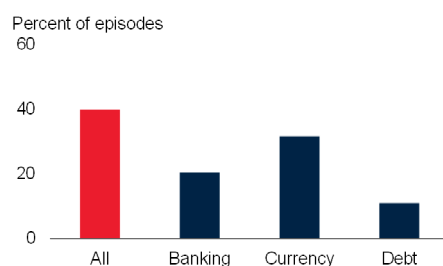
C. Share of financial crisis episodes, by region, 1960-2018



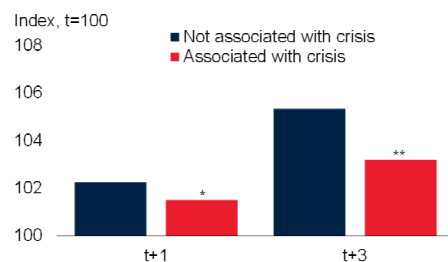
D. Average number of financial crisis episodes per year, by region



E. Total debt accumulation episodes around crises



F. Cumulative productivity gains during episodes of rapid debt accumulation



Source: Laeven and Valencia (2018); World Bank.

Note: Financial crisis episodes include banking crisis, currency crisis, and sovereign debt crisis (Laeven and Valencia 2018, Annex 3.1). An episode dummy for a specific type of event is 1 if the event occurs at least once (≥ 1) in a country-year pair and 0 otherwise. EMDEs = emerging market and developing economies (including low income countries), LICs = low income countries. EAP = East Asia and Pacific, ECA = Europe and Central Asia, LAC = Latin America and the Caribbean, MNA = Middle East and North Africa, SAR = South Asia, SSA = Sub-Saharan Africa. The sample includes 170 economies: 35 advanced economies and 135 EMDEs, of which 27 are low-income countries.

A-D. Debt crisis refers to sovereign debt crisis.

E. Share of total (government and private) debt accumulation episodes associated with financial (banking, currency, debt) crises.

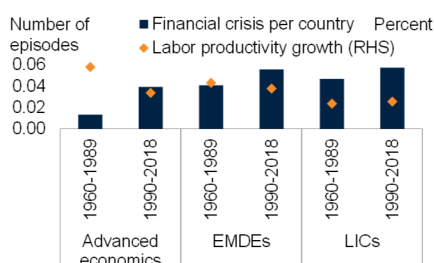
F. ** and * indicates 5, and 10 percent significance levels.

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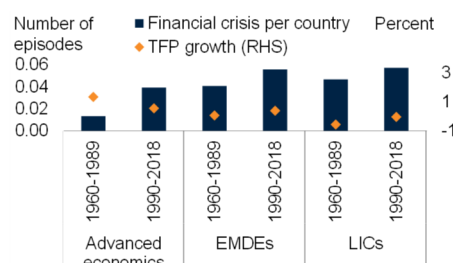
FIGURE 3.7 Correlations between financial crisis frequency and productivity growth

Advanced economies and EMDEs that experienced more financial crisis episodes per year tended to have lower labor productivity growth; these correlations are weak for LICs. The correlations between the frequency of these events and TFP growth are negative for advanced economies but mixed for EMDEs and LICs.

A. Average number of financial crisis episodes per country per year and average labor productivity growth



B. Average number of financial crisis episodes per country per year and average TFP growth



Source: Laeven and Valencia (2018); World Bank.

Note: Financial crisis episodes include banking crisis, currency crisis, and sovereign debt crisis (Laeven and Valencia 2018, Annex 3.1). An episode dummy for a specific type of event is 1 if the event occurs at least once (≥ 1) in a country-year pair and 0 otherwise. EMDEs = emerging market and developing economies (including low income countries), LICs = low income countries. The sample includes 170 economies: 35 advanced economies and 135 EMDEs, of which 27 are low-income countries.

A.B. Correlations between the average number of financial crisis episodes per country per year and (A) average growth of labor productivity (output per worker), and (B) average TFP growth, in 1960-1989 and 1990-2018.

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Measuring the impact of adverse events on productivity

This section analyzes the effects of natural disasters, wars and financial crises on both labor productivity and TFP.³⁴

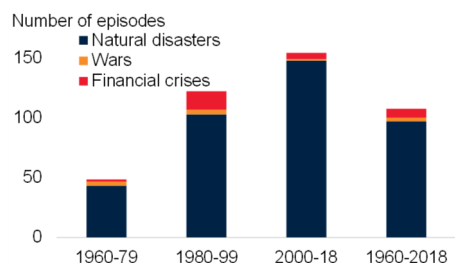
Methodological approach. To assess the effects of adverse events on productivity, the local projection method (LPM) is used, with country productivity level estimates as the dependent variables (Jordà 2005; Jordà, Schularick, and Taylor 2013). For a specific type of event, the explanatory variable of interest is an episode which equals 1 if the event occurred at least once in a particular country in a year and 0 otherwise. The LPM approach provides an estimate of the response of labor productivity (and TFP) to adverse events over various horizons (Annex 3.3). It also helps to identify key transmission channels, assess how countries' resilience to adverse events has changed over time and analyze the role of policies in mitigating their effects. The advantage of this approach is that it avoids the problem of dimensionality inherent in other

³⁴ See chapter 1 for details on the derivation of TFP.

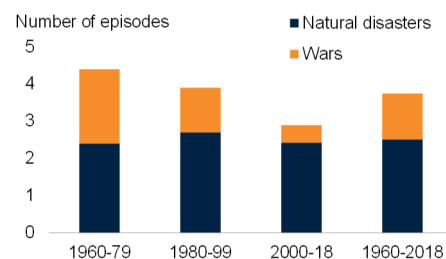
FIGURE 3.8 Episodes across different types of events

In 1960-2018, natural disaster episodes occurred 25 times more frequently than wars, and 12 times more frequently than financial crises. Severe natural disasters occurred twice as often as severe wars. However, on average, wars lasted for about 6 years, twice as long as financial crises, with natural disasters the shortest-lived.

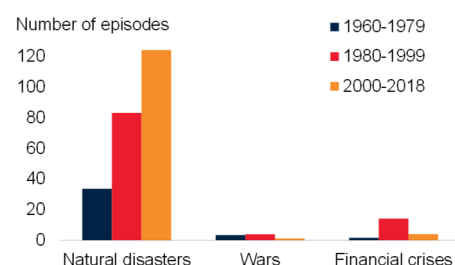
A. Average number of episodes per year



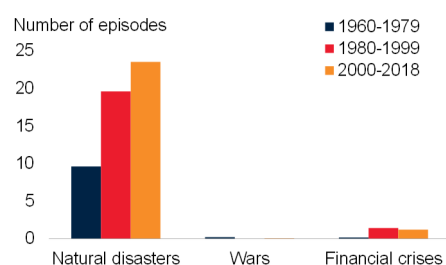
B. Average number of severe natural disaster and severe war episodes per year



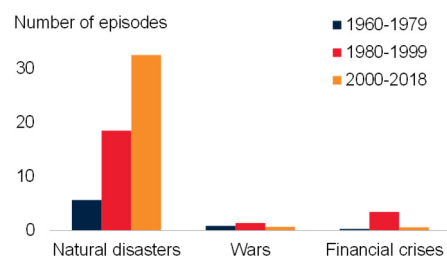
C. Average number of episodes per year in EMDEs



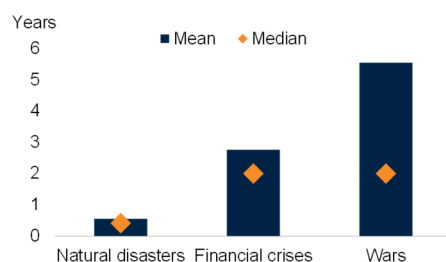
D. Average number of episodes per year in AEs



E. Average number of episodes per year in LICs



F. Average duration



Source: Correlates of War (COW); EM-DAT; Laeven and Valencia (2018); Peace Research Institute Oslo (PRIO); World Bank.

Note: Natural disasters include climate, biological, and geophysical disasters (EM-DAT). Wars include intra-state and external (extra-state and inter-state) wars (COW and PRIO). Financial crises include banking crisis, currency crisis, and sovereign debt crisis (Laeven and Valencia 2018). Definitions are in Annex 3.1. An episode dummy for a specific type of event is 1 if the event occurs at least once (≥ 1) in a country-year pair and 0 otherwise. Severe natural disasters and severe wars are events that led to at least 100 deaths per million population. The sample includes 170 economies: 35 advanced economies and 135 EMDEs, of which 27 are low-income countries.

B. Severe natural disasters and severe wars are defined as events that led to at least 100 deaths in million population.

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approaches such as vector autoregressions.³⁵ However, it does not directly take into account the severity of the adverse event.

In some cases, weak productivity accompanied by a sharp decline in output can trigger financial crises and wars. To guard against such possible endogeneity or reverse causation between productivity and the event, lagged productivity is used as a control. Also, the explanatory variables are lagged—which helps to attenuate the potential endogeneity bias caused by contemporaneous interactions between productivity and crises. The regressions are estimated separately for natural disasters, wars, and financial crises over 1960–2018.

Impacts of natural disasters

Natural disasters can lead to significant contemporaneous losses in labor productivity in both advanced economies and EMDEs (Figure 3.9). The estimates indicate that immediately after a natural disaster, labor productivity tended to decline by 0.5 and 0.3 percent in advanced economies and EMDEs, respectively. These results are consistent with those found in the literature.³⁶ As well as the destruction of the capital stock, which weakens labor productivity, natural disasters also adversely affect TFP.³⁷ However, the magnitude of the estimated effect of natural disasters on TFP may be expected to be smaller than that on labor productivity, because of the effect on the latter of the loss of physical capital. Indeed, the estimates indicate that natural disasters led to a 0.3 percent decline in TFP in advanced economies, in the first year of the disaster, with no significant effect in EMDEs. This may reflect possible offsetting productivity gains resulting from investment by governments and firms in new and more technologically advanced capital—investment induced by the natural disaster—leading to improvements in both TFP and labor productivity (Hallegatte and Dumas 2009).³⁸

Climate disasters. Among the different types of natural disasters, climate disasters have been particularly detrimental in terms of lost labor productivity. The estimates for both advanced economies and EMDEs indicate that climate disasters contemporaneously reduced labor productivity by about 0.5 percent and have persistent effects in both advanced economies and EMDEs. For EMDEs however, the estimated longer-term drag on productivity is smaller and subject to a wider margin of error. In fact, many previous studies have found that economies hit by climate disasters have been able to recover, especially after smaller-scale events (Hallegatte, Hourcade, and Dumas 2007; Loayza et al. 2012).

Threshold effects and severe climate disasters. Previous studies have distinguished among natural disasters in terms of their scale, using different thresholds, and found that the estimated effects on productivity and output are dependent on the size of the natural

³⁵ Vector autoregressions approach entails modeling and estimating a large number of time series, whereas LPM focuses on the dynamics of the variable of interest – productivity in this case.

³⁶ See Dell, Jones, and Olken (2012); Fomby, Ikeda, and Loayza (2013); and Strömberg (2007).

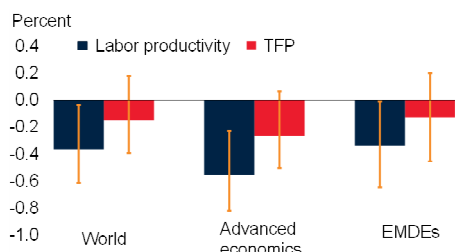
³⁷ See Noy and Nualsri (2011); Skidmore and Taya (2002); and Strobl (2011).

³⁸ See Hsiang (2010); Skidmore and Taya (2002); and Strobl (2011).

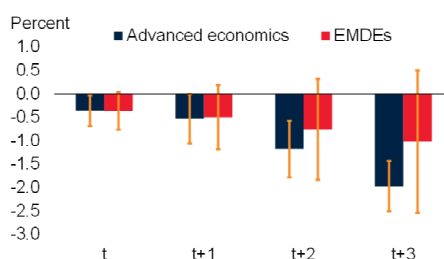
FIGURE 3.9 Estimated effects of natural disaster episodes on productivity

Episodes of natural disasters are estimated to have led to significant losses in productivity, especially labor productivity. Climate disasters, especially severe ones, have been particularly detrimental to productivity, although public and private investment have tended to increase in the short term, reflecting the shorter duration of the shock and reconstruction.

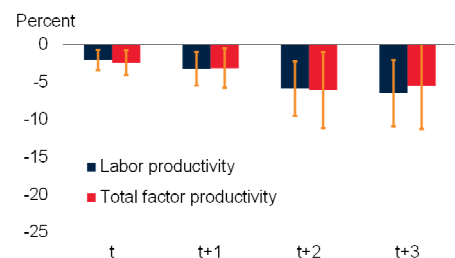
A. Contemporaneous effect of natural disaster episodes on labor productivity and TFP



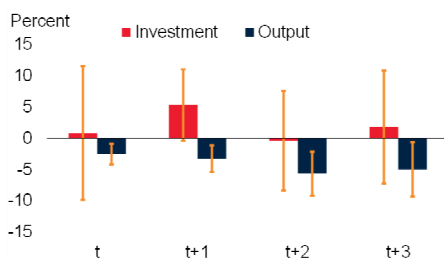
B. Effect of climate disaster episodes on labor productivity



C. Effects of severe climate disaster episodes on labor productivity and TFP



D. Effects of severe climate disaster episodes on labor investment and output



Source: EM-DAT; World Bank.

A-D. Natural disasters include climate, biological, and geophysical disasters (EM-DAT, Annex 3.1). An episode dummy for a specific type of event is 1 if the event occurs at least once (≥ 1) in a country-year pair and 0 otherwise. EMDEs = emerging market and developing economies (including low income countries). Blue (and red) bars indicate the average impact of the event for each group and orange lines represent the 90 percent significance range.

C-D. Severe climate disasters are defined as events that led to at least 100 deaths in million population.

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disaster (Annex 3.1).³⁹ Larger natural disasters have been found to have more severe immediate negative consequences for the economy (Fomby, Ikeda, and Loayza 2013). Smaller events have been shown to have less persistent effects and even positive effects over the longer term (Loayza et al. 2012; Cavallo et al. 2013a). The literature finds that severe disasters have disproportionately larger economic impacts due to non-linear effects on labor force participation and human capital, particularly amongst younger workers (Cavallo et al. 2013; Hallegatte and Przyluski 2010; Loayza et al. 2012). Furthermore, the cumulative loss of productivity tends to be larger if the disaster lasts

³⁹ EM-DAT data can suffer from selection biases leading to a non-linear link between physical intensity and (direct) asset losses (Felbermayr and Gröschl 2014b).

for a more extended period—as is the case with biological disasters—or if reconstruction efforts are delayed (Sawada 2007; Cerra and Saxena 2008).⁴⁰ Some studies suggest that the long-run costs of natural disasters are mainly driven by uninsured losses, subsequent institutional instability, or regime changes.⁴¹ This is supported by the analysis here, which suggests that larger shocks can have a positive effect on productivity in advanced economies, which likely benefit from better emergency response, more effective reconstruction plans, and deeper insurance markets (Annex 3.1).

In the analysis here, severe climate disasters are defined as those that caused at least 100 deaths per one million inhabitants. The results support the intuition that severe climate disasters have larger and more persistent effects on productivity in EMDEs than less severe ones. Labor productivity fell initially by about 2 percent and more than 7 percent below baseline, three years after a severe climate disaster (Figure 3.9). The estimates show that lower labor productivity is mainly accounted for by weaker total factor productivity rather than reduced investment.⁴² Possibly because after a severe disaster, firms delay or trim down R&D spending, which impedes the creation, transfer, and adoption of new technologies, and hinders global value chains. On the other hand, overall investment may remain more resilient as reconstruction spending partly offsets some reduction in other types of capital spending.

The effects of biological and geophysical events are found to be not statistically significant. However, the estimates are for the average event, which could be localized or for other reasons affect only a limited number of people. Large biological or geophysical events may have large negative effects on productivity, including by constraining economic activity and human interaction, disrupting global value chains, and depressing demand, as exemplified by the COVID-19 outbreak.

Effects of epidemics. Epidemics lead to large and lasting negative effects on labor productivity.⁴³ There were five epidemics during the period 2000-2018: SARS (2002-03), Swine flu (2009), MERS (2012), Ebola (2014-15), and Zika (2015-16). These four major epidemics, excluding the Swine flu since it coincides with global financial crisis to avoid compounding effects, lowered labor productivity initially by 1 percent, and by 4 percent cumulatively after three years (Box 3.1). These severe epidemics seem to adversely affect labor productivity primarily through investment, which declined by 9 percent after three years due increased uncertainty.

Cascade effects. Natural disasters can trigger other types of adverse events such as debt crises and wars, thus compounding the effects on productivity (Benson and Clay 2004;

⁴⁰ The pace of reconstruction may be slowed by financial, physical and transaction constraints (Hallegatte and Rentschler 2018).

⁴¹ For example, some have found that the adverse macroeconomic effects of natural disasters dissipate after five years and that climate disasters explain a very small portion of the variance in real per capita GDP (Noy and Nualsri 2007; Peter, Von Dahlen, and Saxena 2012; Raddatz 2007).

⁴² The impact on investment can be noisy due to possible mismeasurements in capital stock (Chapter 1 Box 1.1).

⁴³ Epidemics are different than typical biological disasters in the sense that they last longer and are accompanied by elevated uncertainty.

Celiku and Kraay 2017). Studies show that countries hit by major disasters can experience a sharp widening of the budget deficit, which can then increase the likelihood of a sovereign debt crisis (Benson and Clay 2004). Moreover, natural disasters can widen inequalities and exacerbate political tensions in affected countries. Besley and Persson (2011) estimated, for a sample of 97 countries in the period 1950–2005, that natural disasters increased the probability of wars by about 4 percentage points.

LICs. Fragile states and LICs are among the countries most exposed to natural disasters (Table A.3.1.3, Figures 3.2–3).⁴⁴ Although land-locked LICs have tended to experience fewer natural disasters than non-land-locked LICs, the impacts of such events on LICs have generally been considerably larger than in other income group economies, with more deaths as a percentage of the population and larger losses of output (Gaiha, Hill, and Thapa 2012; Noy 2009). This is partly because a larger proportion of workers are in primary sectors—agriculture and mining—which are more susceptible to natural disasters. Moreover, infrastructure in LICs tends not to be as robust as in advanced economies. LICs also often lack the ability to quickly cope with natural disasters and thus tend to suffer additional losses stemming from disease and displacement.⁴⁵ LICs that are more often hit by natural disasters tend to have lower labor productivity and TFP level than LICs that are less frequently hit by them. The disruptive effects of natural disasters may substantially delay—or even derail—the convergence process in LICs (Chapter 4).

Impacts of wars

The analysis here focuses on the effects of wars on EMDEs.⁴⁶

Intra-state wars. On average, EMDEs that experienced intra-state wars are estimated to have suffered a reduction in labor productivity of roughly 5 percent three years after the beginning of the war (Figure 3.10).⁴⁷ Significant negative effects on TFP occurred with more of a time lag. Based on other research, the loss of TFP may have been partly the result of negative effects on health, especially of children, disruptions to education, and weakened trade (Ades and Chua 1997; Akresh et al. 2012; Collier and Hoeffler 2004). The decline in TFP reaches around 6 percent three years after the beginning of the war.

External wars. These refer to both inter-state and extra-state wars combined. The losses from these two kinds of external wars have been much more pronounced than those from intra-state wars. This may be accounted for partly by the fact that international trade and FDI have been found to decline more in times of external conflict (Bayer and

⁴⁴ There are 41 natural disasters episodes per country in LICs compared to 34 in EMDEs in the whole sample (Table A.3.1.3).

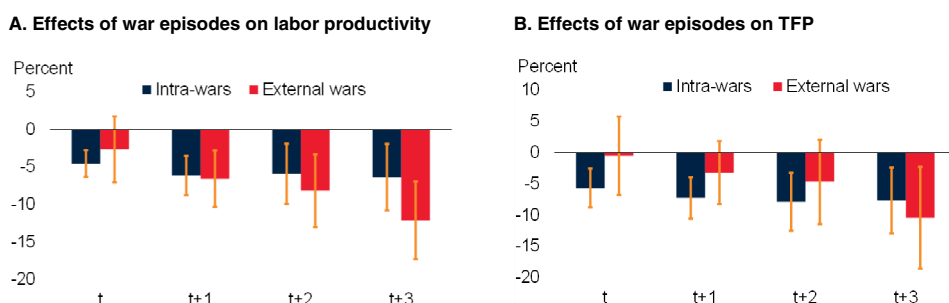
⁴⁵ See Benson and Clay (2004); Ghesquiere and Mahul (2010); and Kahn (2005).

⁴⁶ The focus here is on EMDEs since there have in recent years been no civil wars in advanced economies and the estimates suggest that the effects of external wars for advanced economies are ambiguous.

⁴⁷ Easterly et al. (1993) found, for 80 countries during the 1970s and 1980s, that war-related casualties per capita is correlated significantly negatively (−0.3) with GDP per capita growth. Rodrik (1999) extended this study and found larger declines in GDP per capita growth for countries with high ethnolinguistic fragmentation.

FIGURE 3.10 Estimated effects of war episodes on productivity in EMDEs

Episodes of wars are estimated to have led to the steepest productivity losses among all types of events. The effects of war episodes on labor productivity have occurred immediately after the onset of wars, while their effects on TFP have mainly occurred 1-2 years later. While the damage to productivity from internal wars has tended to be apparent immediately after the onset of the wars, longer-term losses from external wars have been much more pronounced.



Source: Correlates of War (COW); Peace Research Institute Oslo (PRIO); World Bank.

A.B. Wars include intra-state and external (extra-state and inter-state) wars (COW and PRIO, Annex 3.1). An episode dummy for a specific type of event is 1 if the event occurs at least once (≥ 1) in a country-year pair and 0 otherwise. Blue and red bars indicate the average effect of the event for each horizon and orange lines represent the 90 percent significance range.

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Rupert 2004; Busse and Hefeker 2007). Three years after the onset of an external war in an EMDE, the estimated decline in labor productivity exceeds 12 percent on average. The estimated negative effects on TFP are, not surprisingly, somewhat smaller than on labor productivity given that labor productivity, but not TFP, is affected by the loss of capital (Hutchinson and Margo 2006). The estimated decline in TFP after three years is 10 percent, with only a modest subsequent recovery (Figure 3.10).

Impacts of financial crises

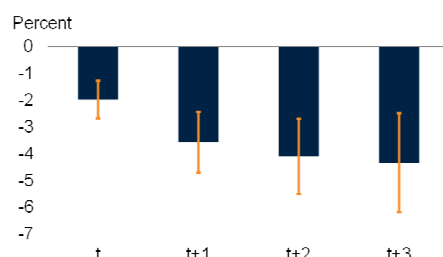
Financial crises tend to lead to large and long-lasting productivity losses. The estimates indicate that in the year of the onset of a financial crisis, labor productivity globally has declined on average by about 2 percent (Figure 3.11). The estimated decline three years later is 4 percent. The estimated effects are more modest for EMDEs than for advanced economies. For advanced economies, the decline in labor productivity three years after the onset of the crisis is around 6 percent, compared to around 3 percent in EMDEs. The larger productivity fall in advanced economies could reflect the larger size and economic importance of financial markets in these economies. The large initial productivity losses associated with financial crises are consistent with the literature.⁴⁸ The estimates showing sustained damage to productivity are consistent with the years of subpar growth since the 2008-09 global recession, as well of the sharp reduction of

⁴⁸ See Ball (2014); Cerra and Saxena (2008); Furceri and Mourougane (2012b); and Hutchison and Noy (2002).

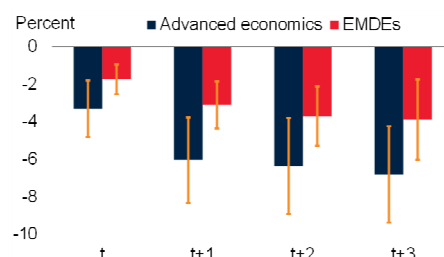
FIGURE 3.11 Estimated effects of financial crisis episodes on labor productivity

Episodes of financial crises are estimated to have led to large and persistent losses in labor productivity. The estimated effects are smaller in EMDEs than in advanced economies. Financial crises (except for currency crises) are estimated to have been more detrimental to labor productivity than to TFP. Sovereign debt crises have led to more severe losses in productivity, especially labor productivity, than other types of financial crisis.

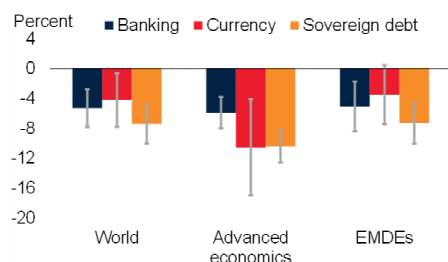
A. Effects of financial crisis episodes on labor productivity, world



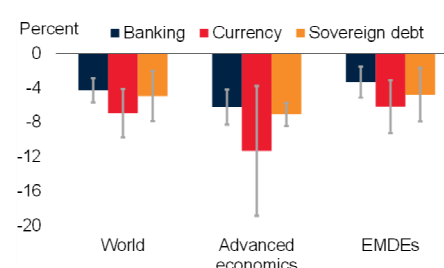
B. Effects of financial crisis episodes on labor productivity



C. Change in labor productivity three years after financial crisis episodes



D. Change in TFP three years after financial crisis episodes



Source: Laeven and Valencia (2018); World Bank.

Note: Financial crisis episodes include banking crisis, currency crisis, and sovereign debt crisis (Laeven and Valencia 2018, Annex 3.1). An episode dummy for a specific type of event is 1 if the event occurs at least once (≥ 1) in a country-year pair and 0 otherwise. EMDEs=emerging market and developing economies (including low income countries).

A.B. Blue bars indicate the average impact of the event for each horizon and orange lines represent the 90 percent significance range.

C.D. Blue, red, and orange bars indicate the average impact of the event for each financial crisis three years after the onset of the crises and gray lines represent the 90 percent significance range.

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economic growth and investment in Asia following the region's 1997-98 financial crisis (Barro 2009; Cecchetti, Kohler, and Upper 2010; Cerra and Saxena 2008).

Sovereign debt crises have typically been associated with falls in labor productivity and TFP of around 7.5 percent and 4.5 percent, respectively, three years after a default or debt restructuring.

Banking and currency crises have tended to be associated with subsequent reductions in labor productivity of between 5-7 percent in EMDEs after three years. This is consistent with other studies in the literature, although some suggest that the effects of banking

crises are often short-lived (Demirgüç-Kunt, Detragiache, and Gupta 2006).⁴⁹ These adverse effects on productivity appear to be larger in advanced economies, again possibly because of their larger and more economically important financial markets. However, advanced economies may have more competitive banking systems, which may reduce the likelihood of experiencing a financial crisis relative to EMDEs (Demirgüç-Kunt and Levine 2001; Beck, Demirgüç-Kunt, and Levine 2006).

Compounding effects of twin crises. Consistent with some of the literature, currency crises in EMDEs were found to lead to smaller labor productivity losses than debt and banking crises. However, sovereign debt crises can exacerbate the effects of currency or banking crises (Kapp and Vega 2014). Thus, the current estimates for EMDEs find that the effect of twin crises, consisting of simultaneous banking and currency crises, has been more severe than the sum of the effects of separate banking and currency crises.⁵⁰ While banking crises have been associated with a contemporaneous decline in labor productivity of around 2 percent, and currency crises with a decline of 0.2 percent, twin banking-currency crises have been associated with a 3.5 percent decrease, suggesting that in a combined crisis interaction substantially compound the harm that ensues.

Comparison across different types of events

From a public policy perspective, the allocation of budgetary resources to disaster prevention efforts should depend on the relative costs of the expected output losses and other problems associated with the events, as well as the effectiveness of the mitigation efforts. However, comparing the costs of different types of shocks is challenging, since the identification of events depends on the threshold used for metrics such as the size of financial losses and the number of casualties. Moreover, the impact of future events may differ from past ones of the same type because of changing socio-economic environments.

In EMDEs, according to the estimates, wars have been about ten times more detrimental to productivity on impact than natural disasters, and 1.5 times more detrimental than a financial crisis. An average financial crisis has thus tended to reduce productivity much more than a typical natural disaster (Figure 3.12). The results, which are broadly in line with the literature, show that on average financial crises induce a loss of about 2 percent in output per capita one year after their onset. This is twice the magnitude of the one-year productivity loss following an average natural disaster.

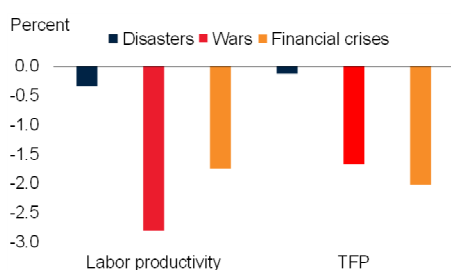
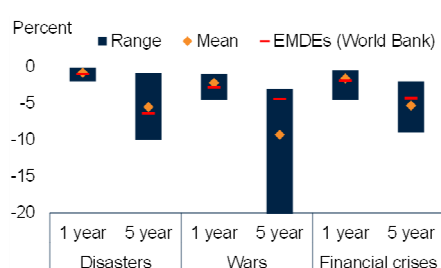
Over a longer horizon, according to estimates from the literature, wars appear to be most disruptive at the 5-year horizon, reducing output per capita by an average of about 9 percent. However, there is a wide range of estimates, with some as high as 20 percent (Barro 2009). This may stem from differences in the criteria used to identify adverse

⁴⁹ See Barro (2001); Crafts (2013); Morris and Shin (1998); Obstfeld (1996); and Reinhart and Rogoff (2009).

⁵⁰ Cerra and Saxena (2008); Kapp and Vega (2014); and Kaminsky and Reinhart (1999) find larger effects. However, Hutchison and Noy (2005) find no additional (marginal) negative impacts above and beyond the combined effect of the two crises.

FIGURE 3.12 Comparison of estimated effects in EMDEs

An average financial crisis has been associated with much more damage to labor productivity than an average natural disaster, but wars have been the most damaging events. The findings of this chapter are consistent with the literature, which finds that one year after their onset, financial crises have tended to reduce output by about 2 percent, twice the adverse impact of natural disasters. Natural disasters have led to declines in output per capita of about 3 percent after five years, pointing to long-run corrosive effects. The peak of the damage to productivity from war appears to occur about five years after the event.

A. Initial impacts of natural disaster, war and financial crisis episodes on EMDE productivity**B. Estimated effects of natural disasters, wars and financial crises on output per capita from the literature**

Source: Correlates of War (COW); EM-DAT; Laeven and Valencia (2018); Peace Research Institute Oslo (PRIO); World Bank.

Note: Natural disasters include climate, biological, and geophysical disasters (EM-DAT). Wars include intra-state and external (extra-state and inter-state) wars (COW and PRIO). Financial crises include banking crisis, currency crisis, and sovereign debt crisis (Laeven and Valencia 2018). Definitions are in Annex 3.1. An episode dummy for a specific type of event is 1 if the event occurs at least once (≥ 1) in a country-year pair and 0 otherwise.

A. Blue, red and orange bars indicate the average contemporaneous effect of the event.

B. The range of estimates is from the literature.

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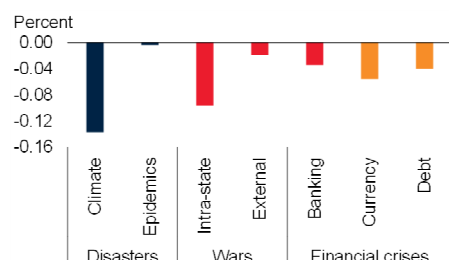
events such as definitions, thresholds for damage and casualties, country coverage, the sample period, and estimation approach (e.g., counterfactual analysis, panel regressions, local projection).

When estimating the overall impact of different types of disasters and considering policy design, it is critical to consider not only the average impact of an average shock but also the frequency of different events (Figure 3.13). While climate disasters tend to have small effects on productivity, they are much more frequent than financial shocks or wars; they also typically affect the poorest countries most. Because of the relatively high frequency of climate disasters in EMDEs, the expected annual loss of labor productivity resulting from them is well above the expected loss from financial crises. On the other side, wars and epidemics tend to be infrequent and to affect only a few countries, so that the average expected losses are small. However, the effects of infrequent wars and epidemics on the countries affected tend to be severe, which underscores the importance of implementing proactive policies to address tail risk events. These results are useful to gauge where risks are relatively high and provide guidance to prioritize mitigation policies.

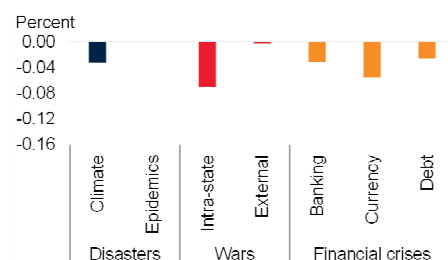
FIGURE 3.13 Productivity loss in EMDEs, scaled by event frequency

Despite the differences in average estimated effects among different types of adverse events, the estimated average effects scaled by the different frequencies of the types of event are more similar, with the exception of external wars, where the adjusted effect is smaller. The expected losses are bigger over longer horizons because of the compounding effect.

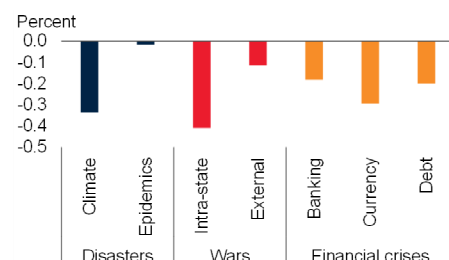
A. Contemporaneous impacts of natural disaster, war and financial crisis episodes on labor productivity



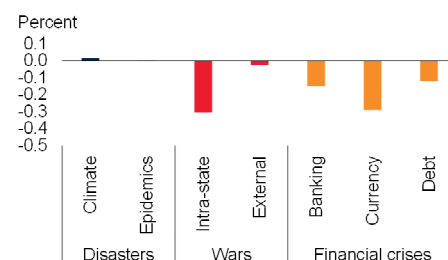
B. Contemporaneous impacts of natural disaster, war and financial crisis episodes on TFP



C. Average cumulative loss of labor productivity, three years after natural disaster, war and financial crisis episodes



D. Average cumulative loss of TFP, three years after natural disaster, war and financial crisis episodes



Source: Correlates of War (COW); EM-DAT; Laeven and Valencia (2018); Peace Research Institute Oslo (PRIO); World Bank.

Note: Natural disasters include climate, biological, and geophysical disasters (EM-DAT). Wars include intra-state and external (extra-state and inter-state) wars (COW and PRIO). Financial crises include banking crisis, currency crisis, and sovereign debt crisis (Laeven and Valencia 2018). Definitions are in Annex 3.1. An episode dummy for a specific type of event is 1 if the event occurs at least once (≥ 1) in a country-year pair and 0 otherwise.

A-D. Blue, red and orange bars indicate the average impact of the event, which is the effect of event multiplied by the probability of that particular event in EMDEs.

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Severe adverse events

Rare and severe events may have disproportionately large impacts on the afflicted countries compared to the small and frequent ones (Hallegatte and Przyluski 2010; Loayza et al. 2012). Large-scale natural disasters tend to cause larger damage to capital, employment and output. Severe wars and intense armed conflicts with large death tolls also cause outsized damage to physical capital, labor and output (Hutchinson and Margo 2006). The negative effects of severe events on labor force participation and human capital are particularly more acute amongst the most vulnerable population groups such as women and younger workers.

Global adverse events

Some large-scale adverse events affect many countries simultaneously. The effects of these global shocks have been amplified through various propagation channels—financial markets, value chains, transport services, trade—as economies have become more integrated. This was exemplified by the 2008 global financial crisis, which started in the U.S. subprime sector and spilled over to global financial markets and economies around the world and was followed by a global productivity slowdown (Chapter 1). Large scale natural disasters such as the COVID-19 pandemic will likely leave deep scars on productivity and output via a dislocation of labor, a tightening of credit, a disruption of value chains and a decline in innovation in addition to triggering financial crisis (Box 3.1).

The recent policies implemented in response to COVID-19 show that quick intervention by international, national, and local authorities with various policies are essential as global adverse events are likely to occur in the future and have lasting negative effects on productivity. They underscore the need for countries to be better prepared to cope with global shocks. Policy support can help to mitigate some of the scarring effects of these global shocks.

What policies can mitigate the effects of adverse events?

Policies can help to reduce the risks of some natural disasters, including through actions to tackle global warming, better protect vulnerable areas and populations, and reduce the likelihood of wars and financial crises. Mitigation policies are likely to require adequate fiscal space and involve appropriate structural reforms.

Addressing vulnerabilities and mitigating the effects of adverse events. In the aftermath of large-scale destructive events like the COVID-19, wars and natural disasters, emergency response and reconstruction can help prevent lasting productivity losses. Countries vulnerable to natural disasters could bolster investment in resilient infrastructure, strengthen health-care systems, and foster climate-friendly innovation.⁵¹ They could also strengthen social safety nets. In LICs, in particular, fiscal buffers might be limited, so foreign aid flows could be helpful by complementing domestic resources (Raddatz 2009). If appropriate, populations and critical infrastructures could be relocated to areas less prone to natural disasters. Regulatory reforms and macro-prudential policies to monitor and address, in a timely manner, systemic banking risks, and debt and external vulnerabilities, can reduce the likelihood of financial crises.

Improving institutions and the business climate. Structural reforms that raise the quality and effectiveness of governance and improve the business climate can reduce the

⁵¹ Reducing those vulnerabilities is efficient in economic terms as each dollar invested in resilience tends to generate four dollars in benefits (Hallegatte, Rentschler, and Rozenberg 2019).

likelihood of some adverse events and also help to limit the damage caused by those that occur. Governments that have improved labor and product market flexibility, strengthened legal systems and property rights, fostered effective competition, and addressed inequality will have laid the foundations for more effective private sector adjustment to adverse events (Anbarci, Escaleras, and Register 2005). Good regulations and institutions can improve risk-sharing and the prevention and mitigation of financial crises and some natural disasters. They can also reduce the probability of wars, which can be rooted in inequalities, unresolved grievances, and greed (Collier and Hoeffler 2004). Reform-driven productivity gains critically depend on the sustainability, timing, size, mix, and duration of such interventions.

Building fiscal space. Emergency responses and reconstruction efforts after wars or natural disasters can be costly. Deep financial crisis may require a sizable fiscal response as well—several advanced economies and EMDEs implemented fiscal stimulus to counter the negative consequences of the 2008 global financial crisis. This underscores the importance of having adequate fiscal buffers to be able to counter negative shocks as well as effective, transparent governance to ensure that funds are spent effectively and in appropriate amounts (Reinhart and Rogoff 2010; Oulton and Sebastián-Barriel 2017; Hallegatte and Rentschler 2018).⁵² Fiscal space may be defined as a government’s ability to fund expansionary fiscal policies without undermining sustainability of public finances. When the previously described LPM regressions were amended to introduce an estimate of fiscal space as a variable, (Jordà 2005; Duval and Furceri 2018), it was found that countries with positive fiscal space tended to experience smaller detrimental effects on productivity after banking or currency crises, or climate disasters (Figure 3.14). The estimates suggest that positive fiscal space provides support to productivity of around 0.9 percent in the case of currency crises, and 0.8 percent in banking crises. Positive fiscal space is also estimated to help alleviate the detrimental effects of climate disasters on productivity, although to a smaller degree. There are similar effects on TFP. In addition, fiscal space is found to help reduce the likelihood of adverse financial events.

Conclusions

Major adverse events—natural disasters, wars, and financial crises—can have long-lasting negative effects on productivity. This chapter has presented a comprehensive analysis of the effects of adverse events on labor productivity and TFP. It explored the channels through which events can erode productivity, how different types of events affect productivity differently and the extent to which they have larger effects on EMDEs and LICs. The chapter also explored the role that policies can play in mitigating these adverse effects.

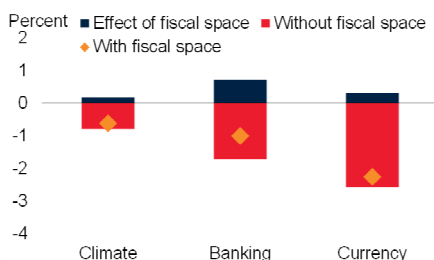
The results suggest that wars tend to be highly damaging to productivity. In addition to their human toll, wars destroy physical capital, disrupt production and trade. Intra-state

⁵² Not only do needs for emergency and reconstruction expenditures rise after natural disasters but also government revenues tend to fall (Noy and Nualsri 2011).

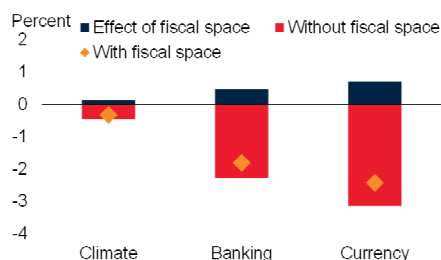
FIGURE 3.14 Productivity loss taking account of fiscal space in EMDEs

Positive fiscal space is associated with a modestly smaller detrimental impact on productivity after financial crisis episodes, especially in the case of currency crises. Countries with positive fiscal space saw a smaller decline in labor productivity after financial crises, with an estimated benefit from the fiscal space of 0.8 percent for banking crises and 0.3 percent for currency crises. Similarly, countries with positive fiscal space benefit by 0.5 and 0.7 percent, in terms of decline in TFP, after the banking and currency crises, respectively. Having fiscal space makes it more feasible to help alleviate the detrimental effects of climate disasters on productivity. Declines in labor productivity and TFP immediately after the onset of a climate disaster have been 0.2 and 0.1 percent smaller, respectively, in countries having a fiscal buffer.

A. Contemporaneous impacts of climate, banking and currency episodes on labor productivity



B. Contemporaneous impacts of climate, banking and currency episodes on TFP



Source: EM-DAT; Laeven and Valencia (2018); World Bank.

Note: Climate disasters (EM-DAT), banking and currency crises (Laeven and Valencia 2018) are defined in Annex 3.1. An episode dummy for a specific type of event is 1 if the event occurs at least once (≥ 1) in a country-year pair and 0 otherwise.

A.B. Blue bars indicate the impact of having a fiscal space on the effect of the adverse events on productivity (effect of fiscal space); red bars represent the gross effect of adverse events on productivity without the fiscal space impact (without fiscal space); and orange mark shows the average net effect of adverse events for the countries which has fiscal space (with fiscal space).

B. TFP = total factor productivity.

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and external wars are estimated to have lowered labor productivity after three years by about 6 and 12 percent respectively. The estimated effect of natural disasters on labor productivity and TFP is smaller, but such events are the most frequent and are therefore a substantial hindrance to productivity. Negative effects from natural disasters have varied by type and also across countries, with LICs particularly vulnerable, so that there have been important adverse effects on poverty. Productivity is also highly vulnerable to financial stress, particularly when accompanied by a rapid build-up of government debt. Severe disasters, such as the COVID-19 pandemic, not only dislocate labor and supply chains, but can also trigger financial stress with severe lasting effects on productivity. Epidemics that occurred since 2000 have lowered labor productivity by a cumulative 4 percent after three years, mainly through their adverse impact on investment and the labor force. In contrast, severe climate disasters were shorter-lived and reduced labor productivity by a cumulative 7 percent after three years, mainly through weakened total factor productivity. The COVID-19 pandemic is likely to have a significantly worse impact on productivity than most previous natural disasters due to its global reach and the widespread disruptions to production and transportation, unprecedented measures to control it, and changes to consumer behavior that it has caused. If not properly

addressed, the negative effects of adverse disasters on productivity can delay or even derail the convergence of EMDEs to the advanced economy technology frontier and may undermine hard-won gains in poverty reduction in LICs and FCS countries.

Macroeconomic and other policies are important tools to counter the adverse effects of natural disasters, financial crises, and wars. Policies are warranted to reduce the pace of global warming, and to better protect vulnerable areas and populations against natural hazards, as well as to encourage relocation from, and hazard-resistant building in, disaster-prone areas. Enhanced regulatory frameworks can help to reduce the likelihood of financial crises, as well as to mitigate their harm. Appropriate institutional and business climates, including good governance, can also alleviate the initial effects of adverse events, and increase the pace of economic recovery. Fiscal space and transparent governance enable reconstruction efforts, after a natural disaster or armed conflict, to get underway in a timely and effective fashion as well as helping to prevent financial crises.

Future research could explore in greater detail the relationship between country characteristics and vulnerability to adverse events. This chapter found that countries with rising government debt tend to suffer more from financial crises. A deeper dive could reveal more information about the importance of characteristics such as governance, infrastructure quality, and regulatory quality for mitigating the impact of disasters, and provide insights to build greater resilience to these types of negative shocks.

Unexpected adverse events are generally considered short-term shocks to the economy. However, longer-term productivity is also affected especially by repeated events, which will impede the convergence of economies, as examined in the next chapter.

ANNEX 3.1 Data, sources, and definitions

Identification of natural disasters. The data are taken from the Emergency Disasters Database (EM-DAT) for the period 1960-2018. There are two main categories in the EM-DAT database: i) natural and ii) technological or man-made hazards. Our analysis is solely based on natural disasters. Natural disasters are split into six categories in EM-DAT. Two of these are used as defined in EM-DAT: i) biological (diseases, epidemics); and ii) geophysical (earthquakes, tsunamis, and volcanic activity) disasters. Three are used as one combined climate category in our analysis: i) climatological (extreme heat and cold, droughts); ii) hydrological (floods); and iii) meteorological (cyclones, storms). The sixth category of natural disasters is not included in our analysis due to limited observations: extraterrestrial, defined as hazards caused by asteroids, comets, or meteoroids; or changes in interplanetary conditions that affect the earth's magnetosphere, ionosphere, and thermosphere. The following inclusion criteria are used: i) ten or more people reported killed; ii) one hundred or more people affected, iii)

an official declaration of a state of emergency; or iv) a call for international assistance.¹ 70 percent of natural disasters were climate disasters; whereas biological and geophysical disasters were much less frequent (Tables A.3.1.1-3, Figure 3.2). There were 3897 climate, 1003 biological, and 830 geophysical disasters over 1960-2018.² The results are sensitive to the thresholds on the number of deaths that are applied to identify a natural disaster. For severe natural disasters with a threshold of one death per million inhabitants, the number of natural disasters declines substantially to 1730, 576, and 256 for climate, biological, and geophysical, respectively.

Comparability of natural disaster databases. Despite substantial improvements, the collection of systematic and harmonized natural disaster data, identifying these events remains challenging. Recorded data differ across different international natural disaster databases due to different methodologies and definitions. The EM-DAT uses a threshold of at least 10 deaths, or 100 people affected, or a declaration of state emergency, or a call for international assistance at the country-level—this definition discards small-scale disasters. By contrast, the DesInventar dataset, maintained by the United Nations Office for Disaster Risk Reduction, uses a lower threshold of at least 1 death or 1 dollar of economic loss, and therefore, has a greater number of recorded events than the EM-DAT (Moriyama, Sasaki, and Ono 2018). Other databases such as NatCat maintained by Munich Reinsurance Company and Sigma maintained by Swiss Reinsurance Company use different criteria based on the number of deaths or cost of property damages. Comparing the data from EM-DAT, NatCat, and Sigma, only 26 percent of the total events reported during 1985-1999 for four countries (Honduras, India, Mozambique, and Vietnam) were common across three datasets (Guha-Sapir and Below 2002). The NatCat and Sigma suggests an increase of natural catastrophes worldwide over the last decade, likely reflecting they are better at capturing less severe events. The NatCat datasets finds the number of severe events has been stable for the last decade, suggesting better mitigation policies.

Challenges to the assessment of the economic costs of natural disasters. From an economic perspective, natural disasters are events that cause a shock to the functioning of the economic system, with significant negative impacts on assets, production factors, output, employment and consumption (Hallegatte and Przyluski 2010). Natural disasters have direct and indirect economic effects. Direct effects include the immediate reduction in output caused by the natural disaster, whereas indirect effects pertain to losses not provoked by the natural disaster itself, but by its consequences. Consider a hurricane or tornado in a country depended on tourism revenue: besides the direct effects of damage caused by the hurricane, a diminished number of tourists will tend to

¹ These selection criteria may, to some extent, bias the estimates towards natural disasters with larger socio-economic impacts. The number of affected people is determined by the sum of injured, homeless, and those who required immediate assistance during the state of emergency.

² Felbermayr and Gröschl (2014) show that natural disaster information obtained from the EM-DAT data set suffer from selection bias as the magnitude of destruction depends on GDP per capita, which leads to upwards-biased estimates.

dampen output growth until reconstruction of facilities is completed and memories of the disaster dissipate.

The literature suggests that the impact of natural disasters on productivity and output tends to be negative.³ However, it is difficult to compare results across various studies due to different methods and metrics.⁴ Cumulative net effects of natural disasters on productivity and output depend on the magnitude and type of natural disaster, and on income level.

- *Magnitude.* Large or multiple natural disasters have sizable negative effects on productivity, both in the short and long-term.⁵ On the other hand, the effects of small or moderate natural disasters are ambiguous. In the short-run, the direct effects of these natural disasters include an immediate loss of output.⁶ However, reconstruction activities can subsequently boost growth, innovation, and productivity.⁷
- *Type.* The impacts of natural disasters on output and productivity can vary substantially across types of disasters (Hochrainer 2009; Loayza et al. 2012). Climate disasters tend to be negative for growth, while other natural disasters have more variable impacts (Felbermayr and Gröschl 2014b; Raddatz 2009).⁸ This might reflect the negative disruptive effects of the natural disasters being offset by the positive effects of reconstruction as governments and aid agencies provide investment.
- *Income level.* More generally, advanced economies suffer smaller negative effects on output growth (Noy 2009). This could be because they have the resources, human capital, and institutions to mitigate the direct effects of adverse events through reconstruction and investment. In addition, the impacts of natural disasters on productivity and output growth can also vary substantially across economic sectors (Loayza et al. 2012). Given the larger role of agricultural activity in LICs, weather events are likely to have more pernicious effects on productivity (Acevedo et al. 2018) than in advanced economies.

³For surveys of the literature see Cavallo and Noy 2011, Dell, Jones, and Olken 2014, and Kousky 2014). Recent papers include Pigato (2019) and Batten (2018).

⁴See Felbermayr and Gröschl (2014b); Fomby, Ikeda, and Loayza (2013); Loayza et al. (2012); Noy (2009); and Raddatz (2009).

⁵For example, Cavallo, Powell, and Becerra (2010) estimated that the earthquake that hit Haiti on January 12, 2010 caused damage to its economy equivalent to 100 percent of the country's GDP (Cavallo and Noy 2011; Fomby, Ikeda, and Loayza 2013; Von Peter, Von Dahlen, and Saxena 2012).

⁶See Cashin, Mohaddes, and Raissi (2017); Cavallo et al. (2013a); Noy and Nualsri (2011); Raddatz (2007, 2009); and Strobl (2011).

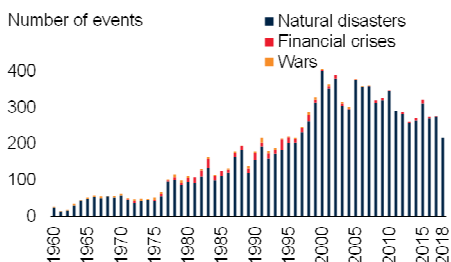
⁷See Benson and Clay (2004); Cuaresma, Hlouskova, and Obersteiner (2008); and Skidmore and Toya (2002).

⁸Even within the category of climatic disasters the effects can differ. Fomby, Ikeda, and Loayza 2013 and Loayza et al. (2012) find that the effects of droughts are negative. In contrast, Cunado and Ferreira (2014) find that floods can lead to a positive effect in advanced economies, as the additional rainfall could boost crop production in the following years.

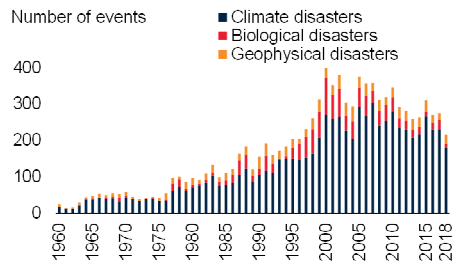
FIGURE A.3.1.1 Time series of number of occurrences, by income group

Disasters, especially climate-related hazards, were the most frequent events in AEs, EMDEs and LICs. Over the last 3 decades, the number of natural disaster occurrences per year has more than tripled. In LICs, climate and biological disaster occurrences have increased sharply in the last 30 years.

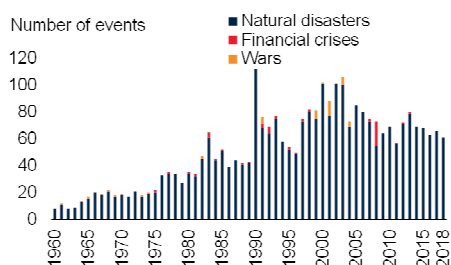
A. Number of occurrences in EMDEs



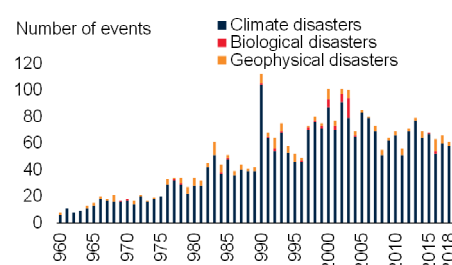
B. Number of natural disaster occurrences in EMDEs



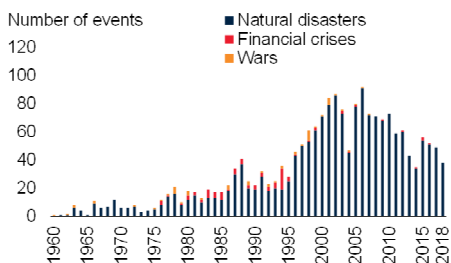
C. Number of occurrences in AEs



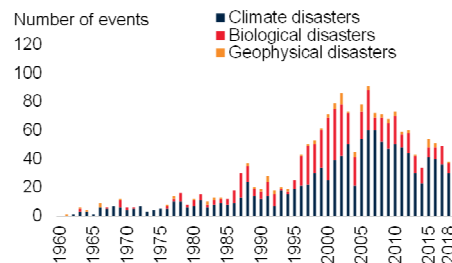
D. Number of natural disasters in AEs



E. Number of occurrences in LICs



F. Number of natural disaster occurrences in LICs



Source: Correlates of War (COW); EM-DAT; Laeven and Valencia (2018); Peace Research Institute Oslo (PRIO); World Bank.

Note: Financial crises include banking crisis, currency crisis, and sovereign debt crisis (Laeven and Valencia 2018). Natural disasters include climate, biological, and geophysical disasters (EM-DAT). Wars include intra-state, extra-state, and inter-state wars (COW and PRIO). Definitions are in Annex 3.1. A specific type of event can have multiple occurrences in a country-year pair. The sample includes 170 economies: 35 advanced economies and 135 EMDEs, of which 27 are low-income countries. AEs = advanced economies, EMDEs = emerging markets and developing economies (including low income countries), LICs = low income countries.

A-F. Time series of the total number of events in EMDEs, AEs and LICs.

[Click here to download data and charts.](#)

Identification of wars. Wars are identified using the World Bank's Correlates of War (COW) database. In this dataset, wars are defined as conflicts with at least 1,000 battle-related deaths over the entire episode (Singer and Small 1994). The COW database covers 1816-2007 and is updated from 2008 to 2018 using the Peace Research Institute Oslo (PRIO) data (Pettersson, Högladh, and Öberg 2019).⁹ Three types of wars are considered in this study: i) intra-state wars, which involve a government in opposition to one or more rebel groups within a state; ii) extra-state wars, which are armed conflicts between a state outside its own territory and a non-state group; iii) inter-state wars, in which both sides are states in the Gleditsch and Ward membership system (Gleditsch et al. 2002). Among the different types of wars, 123 intra-state, 29 extra-state, and 84 inter-state wars are identified for 1960-2018 (Table A.3.1.1). Virtually all intra-state wars take place in EMDEs and 37 percent intra-state wars happen in LICs.

Identification of financial crises. Data for financial crises are based on the Laeven and Valencia (2018) database for the period 1960-2018.

- *Banking crises* are recorded as having started in a given year if one of the following three conditions are met: i) the share of non-performing loans is above 20 percent of total loans; ii) bank closures reach at least 20 percent of banking system assets; or iii) the costs of restructuring of the banking system exceeds 5 percent of GDP. The sample contains 147 episodes of banking crises for which labor productivity estimates are available. About 23 percent of these episodes occurred in 29 advanced economies; 59 percent in 64 EMDEs excluding LICs; and 18 percent in 21 LICs.
- *Currency crises* are defined to have occurred if the following two conditions are met simultaneously: i) at least a 30-percent depreciation of local currency (from a year earlier), and ii) the magnitude of the depreciation is at least 10 percentage points larger than occurred in the year. There are 226 currency crises in our sample for which labor productivity estimates are available. Nearly 8 percent of these currency crises occurred in 13 advanced economies; 72 percent in 75 EMDEs excluding LICs; and 20 percent in 23 LICs. About 10 percent of currency crises were accompanied by banking crises.
- *Sovereign debt crises* are defined as the occurrence of a sovereign debt default or restructuring. In the case of a restructuring of public debt without default, the crisis year is the year of restructuring. There are 71 sovereign debt default events in our sample for which labor productivity estimates are available. Fewer than 3 percent of these episodes occurred in two advanced economies; 80 percent in 44 EMDEs excluding LICs; and about 17 percent in 12 LICs (Tables A.3.1.1-3).
- *A rapid debt accumulation* episode is defined as an expansion from trough to peak of total debt-to-GDP ratios by more than one standard deviation, with troughs and peaks identified using the Harding and Pagan (2002) algorithm. This yields 190

⁹To extend the Correlate Of War database post-2007, the number of battle-related deaths for each conflict in the PRIO database is aggregated over the whole episode.

episodes. Almost half of the debt accumulation episodes were associated with financial crises.

Decline in financial crises frequency, rising debt risk. Over the 58-year sample period, currency crises occurred more often than banking and debt crises (Figure 3.6). The frequency of financial crises was three times greater in the 1980s and 1990s than in the post-1990 period. After 2000, there were on average three currency crises, two banking crises and one debt crisis each year. While the frequency of financial crises declined after 2008, concerns have risen about elevated debt and exchange rate pressures in several countries in recent years (Sandri 2015, Kose et al. 2020). Over the last 30 years, a financial crisis was 50 percent more likely to occur in EMDEs or LICs than in advanced economies (Figure 3.6). The regions most affected by financial crises were SSA and LAC, with Europe and Central Asia (ECA) experiencing a large increase. Countries in ECA and SSA were markedly more affected by adverse financial events during 2000-18, reflecting their economic links to advanced economies and spillovers from the Euro Area debt crisis.¹⁰

TABLES Descriptive statistics on the frequency of major adverse events

TABLE A.3.1.1 Number of episodes

	AEs	EMDEs	LICs	EAP	ECA	LAC	MNA	SAR	SSA	World
All Financial Crises	54	390	83	37	57	109	28	10	149	444
Systemic Banking Crisis	34	113	27	9	22	30	8	4	40	147
Currency Crisis	18	208	44	25	26	52	16	6	83	226
Sovereign Debt Crisis	2	69	12	3	9	27	4	0	26	71
All Disasters	1031	4699	1098	799	481	1114	313	481	1510	5730
Disasters (Climate)	843	3054	651	512	355	788	211	300	887	3897
Disasters (Biological)	50	953	369	98	39	124	32	94	566	1003
Disasters (Geophysical)	138	692	78	189	87	202	70	87	57	830
All wars	45	191	55	37	21	16	35	23	59	236
Intra wars	0	123	46	20	12	11	18	13	49	123
External wars	45	68	9	17	9	5	17	10	10	113

Note: An episode dummy for a specific type of event is 1 if the event occurs at least once (≥ 1) in a country-year pair and 0 otherwise. The sample is restricted to the observations where labor productivity growth data exist for the period 1960-2018. The total number of episodes (in bold) for each group of events (all financials, all disasters, all wars) may include events that occur simultaneously. The events are defined in Annex 3.1. AEs = advanced economies, EMDEs = emerging markets and developing economies (including low income countries), LICs = low income countries, EAP = East Asia and Pacific, ECA = Europe and Central Asia, LAC = Latin America and the Caribbean, MNA = Middle East and North Africa, SAR = South Asia, SSA = Sub-Saharan Africa.

¹⁰ In the post-crisis period, 2010-18, adverse financial shocks, mainly currency and debt shocks, were more frequent in EMDEs and LICs than in advanced economies (Bussière, Fidrmuc, and Schnatz 2005, Arizala, Bellon, and Macdonald 2018).

TABLE A.3.1.2 Number of countries experiencing at least one episode

	AEs	EMDEs	LICs	EAP	ECA	LAC	MNA	SAR	SSA	World
All Financial Crises	31	133	27	18	21	26	16	7	45	164
Systemic Banking Crisis	29	85	21	7	17	18	8	4	31	114
Currency Crisis	13	98	23	11	14	20	8	5	40	111
Sovereign Debt Crisis	2	56	12	3	8	18	4	0	23	58
All Disasters	34	137	27	18	21	27	16	8	46	171
Disasters (Climate)	33	134	27	18	21	27	15	7	45	167
Disasters (Biological)	20	109	27	15	12	18	10	8	46	129
Disasters (Geophysical)	19	79	15	12	16	18	8	8	17	98
All wars	13	69	17	9	12	10	13	5	20	82
Intra wars	0	54	15	9	9	8	7	5	16	54
External wars	13	37	6	6	6	5	9	3	8	50

Note: An episode dummy for a specific type of event is 1 if the event occurs at least once (≥ 1) in a country-year pair and 0 otherwise. The sample is restricted to the observations where labor productivity growth data exist for the period 1960–2018. For each group of events (all financials, all disasters, all wars), the total number of countries affected (in bold) may be smaller than the sum of countries affected by each type of event because a country can be hit by different events at the same time. The events are defined in Annex 3.1. AEs = advanced economies, EMDEs = emerging markets and developing economies (including low income countries), LICs = low income countries, EAP = East Asia and Pacific, ECA = Europe and Central Asia, LAC = Latin America and the Caribbean, MNA = Middle East and North Africa, SAR = South Asia, SSA = Sub-Saharan Africa.

TABLE A.3.1.3 Number of episodes per country

	AEs	EMDEs	LICs	EAP	ECA	LAC	MNA	SAR	SSA	World
All Financial Crises	2	3	3	2	3	4	2	1	3	3
Systemic Banking Crisis	1	1	1	1	1	2	1	1	1	1
Currency Crisis	1	2	2	2	2	3	2	1	2	2
Sovereign Debt Crisis	1	1	1	1	1	2	1	0	1	1
All Disasters	30	34	41	44	23	41	20	60	33	34
Disasters (Climate)	26	23	24	28	17	29	14	43	20	23
Disasters (Biological)	3	9	14	7	3	7	3	12	12	8
Disasters (Geophysical)	7	9	5	16	5	11	9	11	3	8
All wars	3	3	3	4	2	2	3	5	3	3
Intra wars	0	2	3	2	1	1	3	3	3	2
External wars	3	2	2	3	2	1	2	3	1	2

Note: An episode dummy for a specific type of event is 1 if the event occurs at least once (≥ 1) in a country-year pair and 0 otherwise. The sample is restricted to the observations where labor productivity growth data exist for the period 1960–2018. For each type of event, the number of episodes per country is computed by dividing the number of episodes by the number of countries affected. The events are defined in Annex 3.1. AEs = advanced economies, EMDEs = emerging markets and developing economies (including low income countries), LICs = low income countries, EAP = East Asia and Pacific, ECA = Europe and Central Asia, LAC = Latin America and the Caribbean, MNA = Middle East and North Africa, SAR = South Asia, SSA = Sub-Saharan Africa.

ANNEX 3.2 Robustness

Mismeasurement caveats. The literature has identified several issues surrounding the reporting of adverse events. Natural disasters, physical damages and the number of deaths may be under-estimated in areas with limited natural disaster monitoring systems or over-reported to secure foreign aid (Albala-Bertrand 1993). In addition, there are well-known measurement issues—particularly for LICs—pertaining to the effects of the informal sector (Jennings 2011; Kousky 2014), the lack of accounting of reconstruction

(Raddatz 2009), or the effects of insurance (Felbermayr and Gröschl 2014b). However, measurement has been improved by increasingly sophisticated methods for reporting natural disasters, including advanced satellite imagery (Voigt et al. 2007).

Productivity is prone to measurement issues as well. Any measurement issues in variables used in the estimation of labor productivity (output and employment) and TFP (output, employment, and capital) would be reflected in those productivity measures. It is especially important in countries where services and government sectors account for a large share of the economy due to the difficulties in appropriate measurements of those sectors. Data quality, especially in EMDEs, might include imputed estimations and may be poor beyond the general measurement issues such as the difficulty in taking into account various work-arrangements in measuring labor input (Katz and Krueger 2016; Brandolini and Viviano 2018). Measurement of capital inputs is complicated due to its large heterogeneity in various aspects such as tangible vs intangible, short lived vs. long-lived assets (Hulten 2010). The capital input measure used in this study is from PWT 9.1 accounts for different types of assets based on their life span (Inklaar, Woltjer, and Gallardo 2019).

Endogeneity and simultaneity between events. An adverse event may be triggered by other negative shocks. This raises endogeneity concerns when estimating the impact of an adverse event on productivity. Natural disasters can fuel political unrest and conflicts, further damaging the productive capabilities of affected countries (Brancati 2007; Nel and Righarts 2008; Cavallo et al. 2013b). Financial crises and adverse external shocks, such as sharp declines in trade or commodity prices, can precipitate conflicts and wars, and lead to severe productivity and output losses (Reynaerts and Vanschoonbeek 2018). Both wars and natural disasters can lead to rapid debt accumulation, which is often associated with financial crisis (Kose et al. 2020). Among the three types of events explored in this chapter, natural disasters seem the most immune to these endogeneity issues.

Endogeneity with productivity. Natural disasters are in all likelihood not caused by changes in productivity.¹¹ However, endogeneity concerns may arise in the analysis of financial crises and wars. Subdued productivity growth may contribute to a financial crisis or lead to an armed conflict via feeble output growth. Weakening productivity growth can lead to underperforming loans, as it becomes harder for firms to meet their financial commitments. On a large scale, these underperforming loans can cause substantial deterioration in the balance sheets of financial institutions and trigger financial crises (Aghion, Bacchetta, and Banerjee 2000; Kalemli-Özcan, Laeven, and Moreno 2018). Moreover, low output growth due to weaker productivity growth may lead to lower wealth, increased inequality, heightened social tensions, and polarized communities, and consequently trigger political instability. This reverse causal effect may not be immediate but is likely to materialize only after a few years.

¹¹ Even though economic activity is linked to greenhouse gas emissions and climate change, the global spatial and long temporal scale means that productivity has no impact on climate over the timescales considered in this paper.

ANNEX 3.3 Methodology

This chapter mainly uses a local projection methodology (Jordà 2005). This methodology enables to identify the effects of events on labor productivity and TFP while controlling for endogeneity or reverse causation. Another advantage of using this methodology is that it can help identify whether specific country characteristics matter and bolster recovery.

Local projection method. The dependent variable is the cumulative change between labor productivity or TFP (log) levels between horizons $t - 1$ and $t + h$, denoted as $y_{t+h,j} - y_{t-1,j}$. The explanatory variables include the event dummy and controls. The baseline model is given by

$$y_{t+h,j} - y_{t-1,j} = \alpha_{(h),j} + \tau_{(h),t} + \beta_{(h)} E_{t,j} + \sum_{s=1}^p \gamma_{l(h),s} E_{t-s,j} + \sum_{s=1}^{h-1} \gamma_{f(h),s} E_{t+h-s,j} + \sum_{s=1}^p \delta_{(h),s} \Delta y_{t-s,j} + u_{(h)t,j}. \quad (1)$$

where $h = 0, \dots, 5$ is the horizon, $\alpha_{(h),j}$ and $\tau_{(h),t}$ are country j and time fixed effects, and $u_{(h)t,j}$ is an error term. The coefficient of interest $\beta_{(h)}$ captures the dynamic multiplier effect (impulse response) of the dependent variable with respect to the event dummy variable $E_{t,j}$. The number of lags for each variable is denoted by p and set to 1 for the estimation. The specification controls for (i) country-specific trends, (ii) lagged event dates, (iii) future values of the event dummy between time t and $t + h - 1$ to correct for possible forward bias (Teulings and Zubanov 2014), and (iv) past changes $\Delta y_{t-s,j}$. Additional controls for country-specific interactions and non-linear effects may also be included.

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