INTERNATIONAL MONETARY FUND

Economic Scarring: Channels and Policy Implications

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WP/22/248

2022
DEC

WORKING PAPER

 WP/22/248

IMF Working Paper
European Department

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Authorized for distribution by Jeffrey Franks
December 2022

ABSTRACT: This paper documents the existence of medium-to-long term output losses following large crises using panel data that cover 192 countries from 1970 to 2015 and shows that the magnitudes of economic scarring depend on the nature of the shock, economic activity, and pre-crisis conditions. It also provides a thorough review of potential channels that can lead to scarring and presents novel empirical evidence on the significance of supply-side channels using cross-country sectoral-level data. Finally, the paper discusses policy implications based on the empirical findings.

JEL Classification Numbers:	E32, O47, O52
Keywords:	Economic scarring; covid; pandemic; health crisis; systemic banking crisis; economic shock; hysteresis; growth; crises; scarring channels; employment; sectoral output loss; macroeconomic policy
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WORKING PAPERS

Economic Scarring Channels: Channels and Policy Implications

Prepared by Nujin Suphaphiphat and Yu Shi[1]

[1] The authors would like to thank Jaewoo Lee, Iva Petrova, Jörg Decressin, and other members of the EUR Growth Working Group for their valuable comments and suggestions. All errors in the paper are of the authors.

Contents

I. Introduction

The COVID-19 crisis is among the most severe economic shocks in recent history. Its impact on the economy, particularly service activities, resulting from lockdowns, labor shortages, and global supply chain disruptions, has been unprecedented. While the recovery from the pandemic is still incomplete for many economies, the world has witnessed another disruptive shock. The war in Ukraine has taken tolls on human lives, and the disruptions of trade with Russia will potentially have sizeable economic impacts, particular in Europe and those who depends on Russia's energy and commodity sectors.

An unwanted consequence of such large economic shocks is often scarring, which refers to persistent output losses after these shocks. A key debate in the past few decades has been on the existence of scarring, its origins, and its channels of transmission. Our paper aims to contribute to the discussions and provide deeper understanding on the channels as well as their significance for different types of economic crises.

Our contributions are threefold. First, we use a long panel that starts from 1970 and covers over 192 countries to systematically document medium-to-long term output losses – scarring – for different types of crises. Second, we show that the magnitude of scarring is heterogeneous at the sectoral level, which could suggest different underlying transmission channels when the origins of crises vary. Finally, although there have been many efforts at identifying channels of scarring in individual crisis episodes, less is known on the degrees of significance of those channels based on the types of shocks and individual economy's pre-existing conditions. We try to fill the gap by formally testing the channels of scarring using a granular sectoral level data set that covers multiple crises and countries.

This paper also provides a framework for policy design to reduce post-crisis scarring. An important challenge for policy makers is that every economic crisis appears to be different, due to the variations in either the origin of the shock, or pre-existing frictions, or a combination of both. For example, a high-debt country with limited fiscal space would face a tradeoff between providing crisis-relief measures and debt sustainability, particularly when the duration of the crisis is uncertain (like the COVID-19 crisis and the war in Ukraine). By exploring the significance of the above-mentioned channels based on different types of crises and pre-existing economic conditions, our analysis could shed lights on the key factors policy makers should prioritize when designing an efficient crisis-relief package.

Cerra and Saxena (2008) was one of the first studies providing evidence on the persistent impact of output loss from many types of shocks. Their results were confirmed with more updated data (Cerra, Panizza, and Saxena (2013), and Cerra and Saxena (2017)). Reinhart and Rogoff (2009) examine long-term effects of financial crises. Blanchard, Cerutti and Summers (2015) showed that about two out of three recessions have been followed by lower output (hysteresis) or even lower growth (super hysteresis). Haltmaier (2013) found that for advanced economies, the magnitude of an output loss was correlated with the depth of a recession, while in emerging markets, it correlated with the length of the recession. Several studies (Fatás and Mihov (2013), Ball (2014), Rawdanowicz et al. (2014), Reifschneider, Wascher and Wilcox (2015), among others) analyzed a long-term impact of the Global Financial Crisis (GFC) and showed that many advanced economies have not properly recovered from the crisis even after 10 years. Using a dataset dated back to the 14th century, Jordà et al. (2020) found that pandemics are followed by sustained periods (over many decades) of depressed investment opportunities, possibly due to excess capital per unit of surviving labor and excess savings driven

by precautionary motives or the reaccumulating of wealth. Correia et al. (2020) found evidence of persistent declines in economic activity following the 1918 influenza pandemic. Several studies also looked at the mechanisms of economic scarring through factors of production. Blanchard and Summers (1986) found that labor hysteresis exists after a recession, which could imply a persistently smaller labor force as discouraged workers exit the labor market. Human capital accumulation may be hindered by skills erosion occurred during extended periods of unemployment, affecting future earnings (Oreopoulos, Page, and Stevens (2008)). Subdued investment could slow down physical capital accumulation and lower productivity from slower adoption of technology. Recessions could also affect productivity through a loss of firm-specific knowhow as a result of bankruptcy and spillovers (Bernstein et al (2019)), a slowdown in research and development, and resource misallocation (see, for example, Furceri et al. (2021)).

The rest of the paper is organized as follows: Section II presents evidence of economic scarring following major types of crises at the aggregate level and shows the existence of sectoral-level heterogeneity. Section III discusses the main channels of scarring that have been identified in the literature. Section IV provides empirical evidence on the key channels. Finally, Section V discusses the policy implications and section VI concludes.

II. Does Scarring Exist? Evidence at the Country and The Sectoral Level

Methodology and Data

We begin our analysis by systemically documenting the medium-to-long term impact of financial, political, and health crises[1] on the output level using a large panel data that covers 192 countries from 1970 to 2015. The real GDP growth rates are calculated using data from the IMF World Economic Outlook. For identifying the beginning of each crisis, we rely on data from Laeven and Valencia (2018) for currency crises and systemic banking crises and Meredith Sarkees' Correlates of War[2] for civil wars. Health crises include SARS (2003), H1N1 (2009), MERS (2012), and Ebola (2014) following Ma et al. (2020). To our knowledge, we are one of the few exercises that include a variety of economic crises with different origins of shocks and a wide spectrum of countries, from advanced economics to emerging markets to low-income countries.

To formally test the correlation between GDP growth and a crisis, we estimate impulse response functions (IRFs) for each type of crisis following the method in Cerra and Saxena (2008) and Mueller (2012). Given the non-stationarity in output levels and serial correlations in growth rates, we estimate a univariate autoregressive model using real GDP growth. The specification is as follows.

$$g_{i,t} = a_i + \sum_{r=1}^{4} \beta_r g_{i,t-r} + \sum_{s=0}^{4} \delta_s D_{i,t-s} + \varepsilon_{it}, \qquad (1)$$

where $g_{i,t}$ is the annual growth rates of real GDP of a country i at time t, a_i represents the country fixed effect, and D is a dummy variable taking a value of 1 for a starting year that a country experiences a crisis and 0 otherwise.

[1] Specifically, we consider four different types of crises in this paper: systemic banking crises, civil wars, currency crises, and health crises.

[2] https://correlatesofwar.org/data-sets

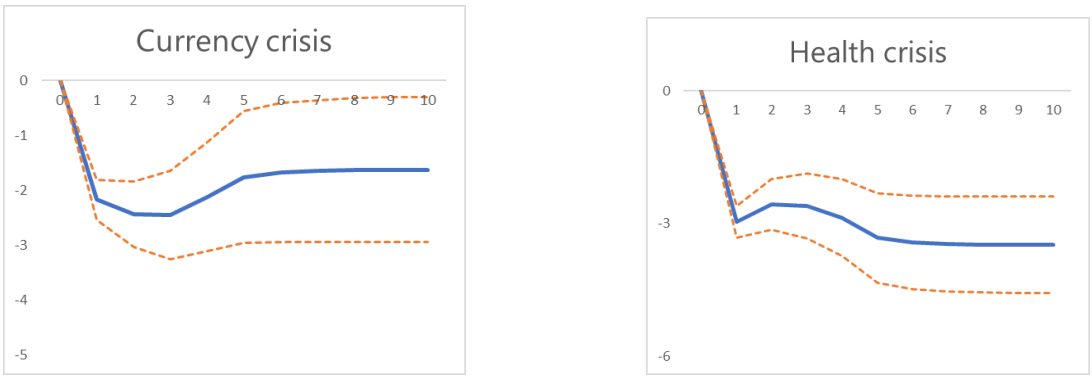
The IRF is estimated for each type of crises, accompanied by a one-standard deviation band drawn from a thousand Monte Carlo simulations.

Main Finding: Scarring exists across the board, but there is significant heterogeneity at the sectoral level.

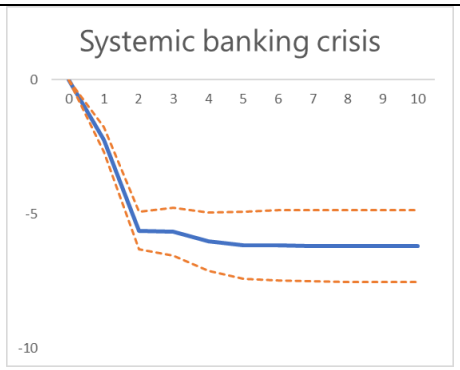
Figure 1 presents the impact of each type of crisis on output from the onset of crisis and subsequent 10 years. The results show a persistent output loss across all types of crises, indicating the existence of economic scarring after a large shock. The magnitudes of the output losses varied significantly, starting from the mildest in currency crises to the largest in civil wars. Specifically, output loss at a ten-year horizon of a civil war is, on average, more than 10 percent compared to a country's pre crisis trend without the shock and is more than six folds that of a currency crisis. Our findings are broadly in line with others that employ similar methods (Cerra and Saxena (2008), Mueller (2012), and Ma et al (2020)). Generally, persistent output losses after large shocks/recessions, or economic scarring, have been widely found under several methods and identifications (see Blanchard, Cerutti, and Summers (2015); Rogoff and Reinhart (2011), among others).

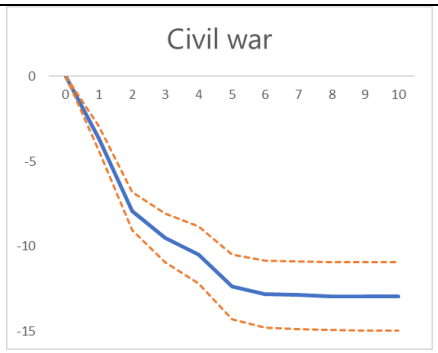
We perform two robustness checks. First, we use a different data set for identifying financial crises (from the Harvard Business School)[3] to confirm the impact on output levels. The results are similar to our baseline results for both currency and systemic banking crises. Second, as multiple crises may occur at the same time, the scarring identified using our baseline specification could the result of more than one crisis. To address the concern, we control our samples by separating a single crisis from multiple crises and test whether the difference of the IRFs between controlled and full samples is statistically significant. Figure 2 below shows how different types of crises could happen at the same time. Although there is significant overlap across crises, for example systemic banking crises and currency crises often overlap, we find sufficient single-crisis episodes which allow us to conduct the robustness analysis. Our robustness checks show that – except for systemic banking crises – the difference between controlled and full samples is statistically insignificant.

Figure 1: Output Loss: Impulse Response Functions for Each Type of Crisis
(Percent deviation from no-crisis counterfactual)



[3] https://www.hbs.edu/behavioral-finance-and-financial-stability/data/Pages/global.aspx





Note: The orange lines are a standard error band drawn from a thousand Monte Carlo simulations.
Sources: Authors' calculations.

Figure 2: Crisis Frequency Across Countries and Time

Civil war				■			■	■		■	■		■
Systemic			■		■	■	■			■		■	■
Currency		■			■				■	■	■	■	■
Health	■					■		■	■			■	
Frequency	495	444	249	155	98	44	13	11	11	7	6	4	3

Note: "Frequency" is defined as the total number of country-year observations for each type of crisis or overlap of different crises.

To further document the significance of scarring, we explore recently available harmonized sectoral level data and study how sectors with different characteristics are affected differently by various types of economic crises.

We apply the same methodology as in the cross-country analysis but change the dependent variable to annual growth rates of real value added for each sector. The country sample for the sectoral analysis is relatively smaller as harmonized sectoral data are limited. We obtain sectoral value added from the Groningen Growth and Development Centre (GGDC) database, which contains data for 37 countries during 1971-2013. It contains 10 sectors, namely, agriculture, mining, manufacturing, utilities, construction, trade/restaurants/hotels, transport/storage/communications, financial services, government services, and others including education, health, and legal. The identification of the global crises (financial crises, health crises, and civil wars) is the same as in the cross-country analysis, except for the health crises where we exclude Ebola in 2014 due to data limitations.

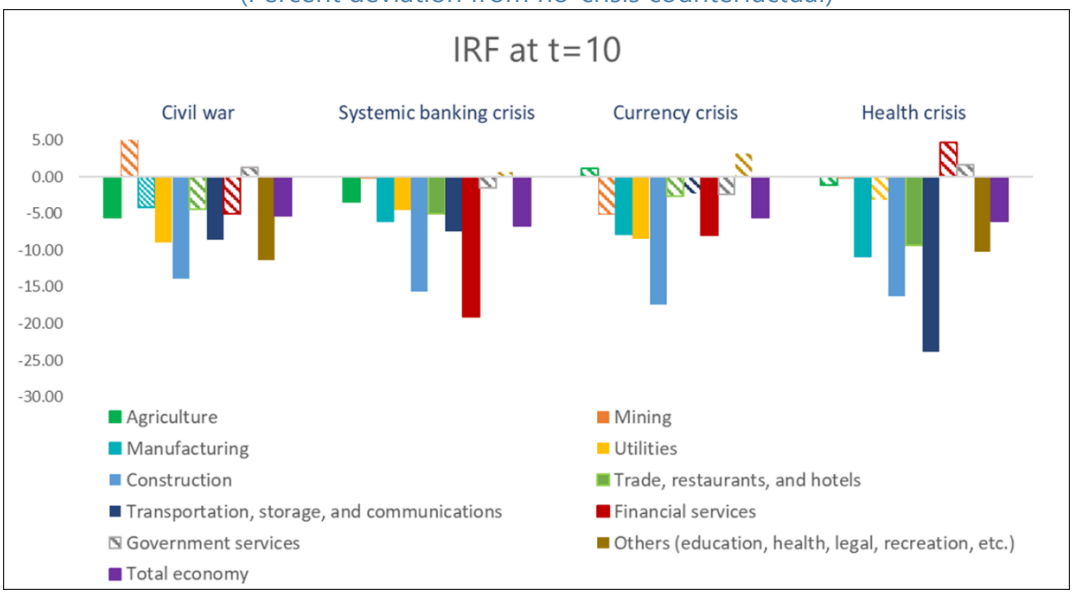
Our findings suggest that average output losses at a 10-year horizon are markedly different across crises and sectors. Figure 3 reveals several interesting insights.

- First, using sectoral real gross value added (GVA) as the dependent variable, it reaffirms our previous key finding that output losses are persistent for all crises. However, the impact on GVA from civil wars appears to be smaller on average compared to other types of crises, in contrast to the previous finding. This is possibly due to smaller country samples where most of them are emerging or advanced economies. Hence, the impact of civil wars is not as devastating as in the previous cross-country analysis.

- Second, each sector has performed quite differently across crises. For example, *financial services* do not statistically generate economic scarring in a civil war but show the deepest scarring in a systemic banking crisis. Scarring in *trade, restaurants, and hotels* only occurs in health and systemic banking crises, while *other services* face persistent losses from both health crises and civil wars.
- Third, *construction* appears to have the deepest scarring across all types of crises. The finding is consistent with the literature. Dell'Ariccia et al. (2020) discuss that -*construction* is one of the sectors most prone to credit busts as the sector is not tradable, highly dependent on external financing, and quite labor intensive. Our analysis also shows that the impact on *government services* is not significant in any types of crises. Intuitively, the government sector usually conducts countercyclical policies to mitigate negative impacts of the crises on output.

Different sectoral reactions to economic shocks can deepen our understanding on the sources of shocks related to each crisis and how these shocks transmit through specific features of the sectors. For instance, in a systemic banking crisis, *financial services*, *construction*, and *transportation/storage/communication* have the deepest scars. While the collapse of the financial sector is a key feature of the systemic banking crisis, the latter two sectors are highly dependent on external financing, which has been found to be one of the key transmission channels from the systemic banking crisis. Civil wars seem to generate scarring in non-tradable sectors such as construction and other traditional service sectors. The health crises leave scars in the sectors that are human capital intensive (*transportation, storage*) and contact intensive (*construction*, *other services*, and *hospitalities*). It is surprising to see that manufacturing has deeper scarring relative to trade, restaurants, and hotels. The finding is rather counterintuitive, particularly when we compare to the current pandemic and calls for further investigation. More disaggregated level data are needed to separate trade from hotels and restaurants and better analyze the impacts.

Figure 3: Output Loss: Impulse Response Function at the Sectoral Level
(Percent deviation from no-crisis counterfactual)



Note: the pattern-filled bars indicate the impact is not statistically significant.
Source: IMF staff calculations.

III. What Explains the Heterogeneity in Scarring?

The large variation observed in sectoral responses to the same economic shock suggest that scarring could be generated via different channels, possibly depending on the type of the original shock, the production processes of individual sectors, as well as pre-existing economic conditions. To formalize our hypotheses on the potential channels of scarring, we discuss in this section some key mechanisms identified in the literature. Then in the next section, we bring together the channels and test them using a harmonized dataset at a more disaggregated industry level.

In a frictionless neoclassical business cycle model, a temporary demand shock should not lead to a permanent output loss given that the economy in the long run would converge back to its steady state. Therefore, scarring is typically the result of unfavorable structural changes or pre-existing frictions being exacerbated following a large shock. The literature has proposed the following channels through which a temporary crisis or recession could result in a long-term output loss from both demand and supply sides:

Supply-Side Factors

Supply-side channels include labor market hysteresis, capital and R&D investment slowdowns due to the weakening of corporate balance sheets, and other factors that affect total factor productivity (TFP) growth such as human capital deterioration (possibly due to worsening of health and education), and resource misallocation (to less productive firms). Labor market hysteresis speaks to the phenomenon that jobs lost in recessions cannot be made up later. It could be a consequence of union bargaining or routinization. Bargaining often resulted in post-crisis recovery happening more in wages but not in employment. However, with the bargaining power of workers weakening in recent years, the channel has become less important. Routinization refers to routine jobs lost in recessions being permanently replaced by machines, usually when the shock is large or persistent enough to trigger some structural changes at the firm level (Charles, Hurst and Notowidigdo (2016)). For routinization, we expect hysteresis to be more significant in sectors with a higher concentration of routine jobs.

Weak capital or R&D investment could be another important driver of economic scarring. After the GFC, many countries entered an era of low investment (IMF, (2015)). One reason is that firms were stuck with weak balance sheets, with limited capacity to finance new investment activities including R&D and innovation (Chaney et al. (2012), Duval et al. (2020), and Queralto (2020)). In addition, large economic crises are often accompanied with heightened economic or geopolitical uncertainties, which could also limit firms' incentives to invest (Dixit (1992), Blattman and Miguel (2009)).

Human capital accumulation could stall when workers lose the opportunities of learning-by-doing at work or when health and education are affected by a related shock. Yagan (2019) found that early-life or long-time unemployment could lower the skill level of workers for their entire lifetime. Additionally, certain types of crises, such as civil wars or health crises, could disrupt education or affect overall workers' health conditions, leading to a loss in human capital (Smolny (2000), Blattman and Miguel (2009)).

Finally, recessions can exacerbate resource misallocation (i.e., too many resources allocated to unproductive firms) and result in lower potential output. One common example of this channel is the different behaviors between large and small firms and between old and young firms during business cycles (Crouzet and Mehrotra,

(2020)). Firms that can survive through crises are not necessarily better or more productive, but often are larger or more connected, which allows them to diversify negative shocks more easily. As young firms or small firms are usually more vulnerable to rising costs (including financing costs and operational costs), they may not get sufficient resources and be forced to shut down or grow slower during recessions. In the case that some of these firms can be potentially promising in the future, this would result in a loss in output and productivity in the long term (Ouyang (2009), Hadlock and Pierce (2010)).

Demand and Policy Factors

From the demand side, a weakening of household balance sheets could delay the process of a demand-driven recovery. For example, following the GFC, private consumption was largely constrained by household debt burden (Mian and Sufi (2010)). Heightened uncertainty could further change the perception of households and result in more precautionary savings (Davis and Wachter (2011)).

Policy responses to crises (including both fiscal and monetary policies), could also play a role in deepening or mitigating the level of economic scarring. Bianchi et al. (2019) show that fiscal austerity after the Euro area crisis, via raising taxes on labor and cutting public spending on investment, has adverse consequences for productivity and economic growth in the medium term and can lead to slow recoveries. In the other hand, the recent study (Ma et al. (2020)) analyzes the impact of fiscal policy from previous health crises and shows that increasing government spending, specifically health spending, could significantly speed up output recovery and reduces unemployment after the crisis.

IV. Verifying the Channels of Economic Scarring—An Empirical Analysis

This section aims to systemically document the channels that can potentially lead to long-lasting output losses after large economic crises. We present macro-level evidence to show that many of the channels are statistically significant when looking at a large sample of countries and industries. In order to do so, we use the harmonized industry-level database from the EU KLEMS Growth and Productivity Accounts, which includes measures of output and input growth, and derived variables such as multi-factor productivity for 27 EU member countries and 34 industries.

We focus on the supply-side channels, which include a permanent loss of routine jobs (the *routinization* channel), depressed capital and R&D investment due to a worsening of corporate financial constraint (the *financial constraint* channel), deterioration of human capital (proxied by sector-specific skill intensity, the *skill* channel), and resource misallocation (including capital, labor, and access to customers) away from productive firms. Given that productivity estimates across sectors are not quite comparable and can be endogenous to the business cycle, we focus on the difference between young and established firms (the *young firm* channel) as clearly young firms are more vulnerable to negative shocks and face more difficulties in access to resources. Finally, policy responses and other demand-side factors are not studied in this exercise given the identification challenge, since they often are the results of endogenous responses (by the public or the private sector) to the initial shock.

Our empirical specification is as follows:

$$g_{ijt} = a_{it} + \sum_{r=1}^{4} \beta_r g_{ij,t-r} + \sum_{s=0}^{3} \delta_s D_{i,t-s} + \sum_{s=0}^{3} \delta_s D_{i,t-s} X_{ij} + \varepsilon_{ijt}, \quad (2)$$

where g_{ijt} is the annual growth rate of real GVA or employment of country i, sector j at time t, D is a dummy variable taking a value of 1 for the starting year of a crisis in country i and 0 otherwise, and X_{ij}'s are sector-specific characteristics that link to the supply-side channels of our interests. α_{it} refers to the country-year fixed effects, which allows us to control for any endogenous policy or demand responses at the aggregate level. Specifically, for each of the supply-side channels, we use the following variables to measure the likely exposure of each sector:

Routinization – The level of routinization in each industry is constructed using a routinization index available at the occupational level, weighted by the share of each occupation in each industry. Granular occupational-level routinization index is available from the Office of National Statistics, United Kingdom (ONS).[4] We aggregate these indices up to one-digit occupations and map them to the composition of employment by sector and by occupation provided by Eurostat (for 22 economic sectors and 10 occupations). Since the Eurostat data is available from 2008 onwards, we take the employment shares in 2008 as initial values which should be orthogonal to any macroeconomic crises that happen later in the sample period.

Financial constraint – In theory, how binding firm-level financial constraint is depends on the difference between the willingness and the ability to borrow from external sources. Businesses that rely more on external financing are usually more capital intensive (higher demand for external financing) or use more assets which can also serve as collaterals in their production processes (higher ability to borrow externally). Therefore, to proxy for sector-specific dependence on external finance, we follow the Rajan-Zingales (1998) approach and use their indicator of external financial dependence based on US firm-level data from Compustat, so the indicator does not vary by country or over time. The indicator is calculated as the ratio of capital expenditures minus cash flow from operations to capital expenditures. It reveals the desired investment that cannot be financed through internal cash flow generated by the median company in the sector. Franco (2018) provided the classification of 2-digit NACE sectors into high, medium, and low levels of external financial dependence. Another factor that is critical to firm financial constraint is the stress of private balance sheets is the initial conditions – given business activities, firms in countries that entered a crisis with higher levels of indebtedness are more likely to suffer from a prolonged period of limited access to finance, hence lower capital and R&D investments. To capture the overall level of vulnerability already accumulated in domestic economy before crises, we use country-level pre-crisis non-financial sector debt-to-asset ratio interacted with sector-specific classification of external financial dependence as a source of variation.

Knowledge/Skills – We explore the variation in sector-specific skill intensity to study the likely impact of human capital deterioration on output, as sectors using more high-skilled workers could suffer more from a shock to the supply of these workers. We follow the Eurostat definition and classify a business activity as knowledge intensive if tertiary educated persons employed (according to ISCED97, levels 5+6 or ISCED11, levels 5 to 8) represent more than 33% of the total employment in that activity. The definition is built based on the average

[4] The dataset is available here. Since the risk of automation is based on a different classification of occupations (i.e., SOC2010), we need to map it into the European classification system (ISCO).

number of employed persons aged 15–64 at aggregated EU-27 level in 2008 and 2009 according to the NACE Rev. 2 at 2-digit level, using the EU Labor Force Survey data. However, there could be another contradicting factor affecting the recovery of sectors with different levels of skill intensity—if the crisis affects the physical ability of workers or requires workers to move to working remotely, the more technologically advanced sectors (likely hiring more high-skilled workers) could accommodate the crisis more easily and therefore should be suffer from a smaller loss in output. Therefore, how a crisis will have different impacts on sectors with different skill intensity becomes an empirical question.

Young/startup firms – We obtain data for a share of young firms (0–5 years) and a share of startups (0–2 years) at a 2-digit NACE sector level for 34 countries from the OECD Structural and Business Development Statistics (SBDS) database. The database provides summary statistics of the birth and death of enterprises, and the number of firms aging 0-5 years. Since these numbers vary over time, we use the statistics at the beginning of the sample period (in year 2008) and divide the industries into two categories: a high/low fraction of young firms or startups.

In each of the specifications, we also control for country-year fixed effects, α_{it} .The country-year fixed effects capture any economy-level macroeconomic fluctuations. They also allow us to control for possible demand shocks, given that the shifts in demand curve, either through policy responses or through the changes of household behaviors, should not be correlated with supply-side features of sectors.

Finally, we focus only on health crises and systemic banking crises for this empirical exercise. This is because the EU KLEMS database includes mostly advanced economies and thus there are limited episodes of wars, currency crises, and solvency defaults, which does not provide enough variations for identification. The results are summarized in the tables below.

Table 1. Health Crisis—Sectoral GVA Growth

	(1)	(2)	(3)	(4)	(5)
VARIABLES	Knowledge	Young	Startup	Routine	Financial
L0. crisis	-14.13**	-12.76***	-13.14***	12.41	-16.89***
	(6.331)	(2.080)	(2.075)	(9.259)	(6.272)
L1. crisis	9.315	5.019**	5.631***	4.535	11.09*
	(6.337)	(2.089)	(2.084)	(9.205)	(6.283)
L2. crisis	-5.228	-0.763	-0.306	-5.719	-2.576
	(6.339)	(2.093)	(2.088)	(9.399)	(6.290)
L3. crisis	-6.642	-2.909	-2.425	-1.864	-5.366
	(6.347)	(2.087)	(2.083)	(9.473)	(6.295)
L0. channel	-2.377	-0.632	-0.0981	-2.373***	5.481***
	(1.875)	(0.701)	(0.673)	(0.569)	(1.843)
L1. channel	2.105	0.261	-0.62	0.458	-3.816**
	(1.950)	(0.730)	(0.700)	(0.565)	(1.923)
L2. channel	3.750*	-1.494**	-2.138***	0.151	-3.812*
	(2.014)	(0.755)	(0.726)	(0.588)	(1.992)
L3. channel	1.579	-0.431	-1.112	-0.369	-2.131
	(1.939)	(0.723)	(0.697)	(0.597)	(1.920)
Lags of Y	4	4	4	4	4
Observations	1,179	6,863	6,863	1,179	1,179

Note: All specifications control for country fixed effects and 4 years' lags of the sectoral value-added growth rates. "Knowledge" represents the knowledge intensity dummy of each industry, which is equal to 1 if tertiary educated persons employed represent more than 33% of the total employment in that activity in 2008-2009. "Routine" records of the share of routine workers by industry in 2008. "Young" and "Startup" use the share of firms aging 0-2 years and 0-5 years, respectively, in each industry in 2008. "Financial" takes the Rajan-Zingales measure by industry. Robust standard errors in parenthesis.

*** p<0.01, ** p<0.05, * p<0.1

Table 2. Health Crisis—Employment Growth

VARIABLES	(1) Knowledge	(2) Young	(3) Startup	(4) Routine	(5) Financial
L0. crisis	-3.065	-11.06***	-11.77***	-0.316	-4.448
	(3.721)	(2.027)	(2.017)	(5.481)	(3.734)
L1. crisis	-0.834	3.940*	3.953*	-3.77	-1.498
	(3.723)	(2.043)	(2.029)	(5.377)	(3.737)
L2. crisis	-0.209	-1.05	-1.241	13.21**	-0.277
	(3.724)	(2.042)	(2.029)	(5.495)	(3.738)
L3. crisis	-0.949	-3.127	-2.999	-1.738	0.0768
	(3.723)	(2.028)	(2.019)	(5.550)	(3.737)
L0. channel	-3.662***	-1.141	-0.138	(0.240)	0.524
	(1.111)	(0.774)	(0.716)	-0.336	(1.101)
L1. channel	-3.905***	-0.471	-0.493	0.144	-1.798
	(1.157)	(0.838)	(0.764)	-0.33	(1.140)
L2. channel	0.0582	-1.928**	-1.652**	-1.137***	0.306
	(1.198)	(0.839)	(0.766)	-0.344	(1.175)
L3. channel	0.94	-1.002	-1.176*	0.095	-2.078*
	(1.148)	(0.766)	(0.711)	(0.351)	(1.130)
Lags of Y	4	4	4	4	4
Observations	1,204	7,000	7,000	1,204	1,204

Note: All specifications control for country fixed effects and 4 years' lags of the sectoral value-added growth rates. "Knowledge" represents the knowledge intensity dummy of each industry, which is equal to 1 if tertiary educated persons employed represent more than 33% of the total employment in that activity in 2008-2009. "Routine" records of the share of routine workers by industry in 2008. "Young" and "Startup" use the share of firms aging 0-2 years and 0-5 years, respectively, in each industry in 2008. "Financial" takes the Rajan-Zingales measure by industry. Robust standard errors in parenthesis.

*** p<0.01, ** p<0.05, * p<0.1

Table 1 and 2 show the development of sectoral gross value-added and employment growth following large health crises. Column (2) and (3) suggest that industries with a larger share of young firms (age 0-5) or startup firms (age 0-2) would recover more slowly compared to other industries. This could be explained by younger firms having disadvantages in the factors market, including the capital market and the labor market, as well as their limited ability to connect to the customers. Column (4) verifies the channel of routinization - technological advances that will replace routine tasks is more likely to happen during a crisis, resulting in a permanent loss of routine jobs. Therefore, sectors with a higher share of routine workers experience both lower employment growth and lower value-added growth after a health crisis shock. Column (5) shows that the balance sheet channel also works following health crises. The result is more significant for value-added growth, indicating that investment could be more sensitive than employment to any changes in market conditions. Finally, the specification using the interaction term of knowledge intensity and the crisis dummy shows mixed results (column 1). For employment growth, sectors with a higher share of high-skilled labor would suffer more after a large health shock, suggesting that these sectors are likely more affected by the disruptions of human capital accumulation as a result of the health shock. The pattern is reversed for value-added growth, for which high-skilled-labor-concentrated sectors tend to perform better. It could be explained by these sectors better adapted to remote work arrangements, but overall, the significance is relatively weak.

Table 3. Systemic Banking Crisis—Sectoral GVA Growth

VARIABLES	(1) Knowledge	(2) Young	(3) Startup	(4) Routine	(5) Financial	(6) Financial
L0. crisis	-10.98	-7.989***	-5.061*	-19.55	-7.553	-5.515***
	(7.630)	(2.155)	(2.678)	(58.660)	(7.626)	(1.232)
L1. crisis	-13.55*	-11.39***	-12.68***	19.83	-16.75**	-13.02***
	(7.315)	(2.298)	(2.288)	(13.200)	(7.292)	(1.236)
L2. crisis	9.126	4.454*	4.270*	16.97	9.503	-2.247*
	(7.315)	(2.296)	(2.286)	(13.000)	(7.298)	(1.192)
L3. crisis	-5.602	-0.497	-0.984	3.135	-3.219	0.197
	(7.315)	(2.295)	(2.285)	(12.990)	(7.298)	(1.192)
L0. channel	4.534	--	-4.972*	0.755	-6.923	5.37
	(10.560)	--	(3.007)	(4.570)	(10.530)	(6.925)
L1. channel	-2.404	-2.453**	-0.632	-2.944***	7.044**	17.79**
	(2.828)	(0.974)	(0.922)	(0.932)	(2.795)	(6.926)
L2. channel	2.453	0.76	1.018	-0.599	0.939	2.122
	(2.751)	(0.953)	(0.896)	(0.914)	(2.729)	(6.774)
L3. channel	5.325*	-1.677*	-0.966	-0.6	-1.534	12.00*
	(2.754)	(0.953)	(0.897)	(0.913)	(2.729)	(6.774)
L0.Financial x pre-crisis leverage						-0.744
						(7.669)
L1.Financial x pre-crisis leverage						-10.83
						(7.669)
L2.Financial x pre-crisis leverage						-1.84
						(7.605)
L3.Financial x pre-crisis leverage						-16.68**
						(7.605)
Lags of Y	4	4	4	4	4	4
Observations	1,228	7,136	7,136	1,228	1,228	1,228

Note: All specifications control for country fixed effects and 4 years' lags of the sectoral value-added growth rates. "Knowledge" represents the knowledge intensity dummy of each industry, which is equal to 1 if tertiary educated persons employed represent more than 33% of the total employment in that activity in 2008-2009. "Routine" records of the share of routine workers by industry in 2008. "Young" and "Startup" use the share of firms aging 0-2 years and 0-5 years, respectively, in each industry in 2008. "Financial" takes the Rajan-Zingales measure by industry. Robust standard errors in parenthesis.
*** p<0.01, ** p<0.05, * p<0.1

For systemic banking crises, scarring is also more likely to appear in sectors with a larger share of young firms or with more routine workers (Table 3 and 4, column (2) – (4)). Our analysis is not able to establish the importance of knowledge intensity, which could suggest that systemic banking crisis tend to result in limited disruptions to human capital accumulation. For the balance sheet channel, it shows the wrong sign at the aggregate level (Table 3, column (5)). However, if we separate countries by their initial conditions measured as non-financial sector leverage at the beginning of the sample period, then in highly leveraged countries, sectors with a higher external financial dependence will experience significantly larger losses after a systemic banking crisis.

Table 4. Systemic Banking Crisis—Employment Growth

VARIABLES	(1) Knowledge	(2) Young	(3) Startup	(4) Routine	(5) Financial
L0. crisis	-2.862	4.854***	-0.828	-0.316	-5.335
	(5.920)	(1.585)	(5.311)	(5.481)	(5.919)
L1. crisis	-2.819	-2.127	-4.773	-3.77	-4.181
	(5.686)	(1.705)	(4.510)	(5.377)	(5.684)
L2. crisis	-0.591	-3.152*	-1.108	13.21**	-1.406
	(5.684)	(1.701)	(4.500)	(5.495)	(5.683)
L3. crisis	-0.216	-0.653	-0.238	-1.738	0.204
	(5.683)	(1.702)	(4.503)	(5.550)	(5.682)
L0. channel	-2.846	--	-1.318	(0.240)	5.867
	(8.206)	--	(5.995)	-0.336	(8.202)
L1. channel	-3.502	-1.256*	-0.0209	0.144	0.577
	(2.201)	-0.759	(1.837)	-0.33	(2.183)
L2. channel	-2.263	(0.995)	-0.212	-1.137***	0.168
	(2.143)	-0.74	(1.786)	-0.344	(2.123)
L3. channel	0.141	(0.632)	-0.297	0.095	-1.125
	(2.143)	(0.740)	(1.786)	(0.351)	(2.124)
Lags of Y	4	4	4	4	4
Observations	1,204	6,773	6,773	1,204	1,204

Note: All specifications control for country fixed effects and 4 years' lags of the sectoral value-added growth rates. "Knowledge" represents the knowledge intensity dummy of each industry, which is equal to 1 if tertiary educated persons employed represent more than 33% of the total employment in that activity in 2008-2009. "Routine" records of the share of routine workers by industry in 2008. "Young" and "Startup" use the share of firms aging 0-2 years and 0-5 years, respectively, in each industry in 2008. "Financial" takes the Rajan-Zingales measure by industry. Robust standard errors in parenthesis.
*** p<0.01, ** p<0.05, * p<0.1

There are several caveats in this empirical exercise. First, due to data limitations, we can only study supply-side channels of economic scarring for 27 EU countries. Given that they are mostly advanced economics, the relative significance of these channels may not apply to emerging or low-income economics. Second, we are not able to capture possible interactions of the supply-side channels. Finally, our specification cannot control for targeted fiscal policy that vary by sector, for example direct support to businesses that are most affected by the initial shock. However, these types of policies usually would mitigate the difference across sectors, so our results are likely showing a lower bound of the actual differential responses.

V. Policy Implications

Macroeconomic policy: The existence of economic scarring after a large crisis implies that an economic cycle will have a persistent impact on long-run output. Therefore, fiscal and monetary policies that can influence macroeconomic environment will potentially affect the magnitude of scarring. Many (Martin and Rogers (1997), Garga and Singh (2016), Engler and Tervala (2018), Jordà, Singh, and Taylor (2020)) show that fiscal and monetary policy shocks have permanent effects on the level of GDP through supply-side factors, including human capital accumulation and research and development. This implies that taking early and aggressive policy action can minimize scarring (Blanchard et al. (2015), Fatás and Summers (2018)). Moreover, studies

and policy makers also suggest that running a high-pressure economy could help boost productivity (Bivens, 2017) and reduce the "depth and persistence of the downturn" (Yellen, 2016).

Supply-side policies: Our empirical analysis sheds lights on the supply-side channels of economic scarring and provides helpful insights for policy design and in assessing policy tradeoffs, particularly for a country with limited policy space. In the context of a health crisis, replenishing human capital accumulation, including through promoting early childhood development programs and life-long learning as well as improving education systems will help mitigate an adverse impact on aggregate productivity. Fostering digital literacy, along with temporarily expanding social safety nets and active labor market policies, can help facilitate worker reallocation. To minimize resource misallocation, policies should aim at supporting young but highly potential firms and facilitating a smooth exit of nonviable firms through improved bankruptcy and debt restructuring mechanisms (IMF (2021) and Bauer et al. (2021)). Corporate balance sheet repair would reduce debt overhang and promote investment (IMF, 2020). Finally, boosting public investment, particularly in climate-friendly infrastructure, can help crowd-in private investment and promote sustainable growth (IMF, 2021).

VI. Conclusion

This paper provides evidence that significant and persistent output losses—economic scarring—occur following a large shock. It shows that, in line with previous literature, economic scarring exists after a large negative shock. The depths of the scars are heterogenous across crises. Specifically, output loss at a ten-year horizon of a civil war is, on average, more than 10 percent compared to a country's pre-crisis trend without the shock and is more than six folds that of a currency crisis. Moreover, scarring at a sectoral level is significantly different across different types of crises. For instance, financial services do not statistically generate economic scarring in a civil war but show the deepest scarring in a systemic banking crisis. Scarring in trade, restaurants, and hotels only occurs in health and systemic banking crises, while other services face persistent losses from both health crises and civil wars. Finally, construction appears to have the deepest scarring across all types of crise. This could be related to the sector's high dependence on external financing and its prone to cyclicality.

The fact that the paths of recovery vary among different business activities, suggesting multiple channels could exist behind the scars observed at the aggregate level. We further test the relative significance of supply-side channels for health shocks and systemic banking crises and discuss policy implications. Focusing on the development of employment growth and value-added growth following a health crisis and a systemic banking crisis, industries with a larger share of young firms or startup firms would recover more slowly compared to other industries. Similarly, industries sectors with a higher share of routine workers experience both lower employment growth and lower value-added growth. For a health crisis, high-skilled labor industries incurred a deeper scar, suggesting that a loss of human capital accumulation plays a key role. For a systemic banking crisis, the paper showed that in high-leveraged countries, scarring is more pronounced in sectors with a higher external financial dependence.

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PUBLICATIONS

Economic Scarring: Channels and Policy Implications

Working Paper No. WP/2022/248