

Building economic resilience to pandemic risk in Switzerland

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Abstract

This paper examines the scope for pandemic insurance in Switzerland, addressing the residual revenue losses faced by firms despite comprehensive fiscal and monetary policies during COVID-19. While these policies provided critical support, they failed to fully mitigate revenue declines from government-imposed business interruptions. We highlight how pandemic insurance could reduce firms' exposure to revenue shocks and lessen reliance on costly interventions. Drawing insights from the Swiss Elemental Pool, a successful framework of risk-pooling for natural catastrophes, we explore its applicability to pandemic risks. Given the systemic nature of pandemics, we argue that inter-temporal risk-sharing, capital accumulation, and risk transfer to financial markets can support a viable public-private partnership (PPP) for pandemic insurance. While conceptually promising, such a PPP requires further empirical evaluation of costs, benefits, and policy interactions. A well-designed framework could enhance resilience to future pandemics and reduce the economic burden of ex-post interventions.

1 | INTRODUCTION

COVID-19 triggered an unprecedented and peculiar mix of supply and demand shocks that rattled the Swiss economy, arising from the conflation of government-imposed restrictions on mobility and social interaction to reduce virus spread, the population's behavioral responses via

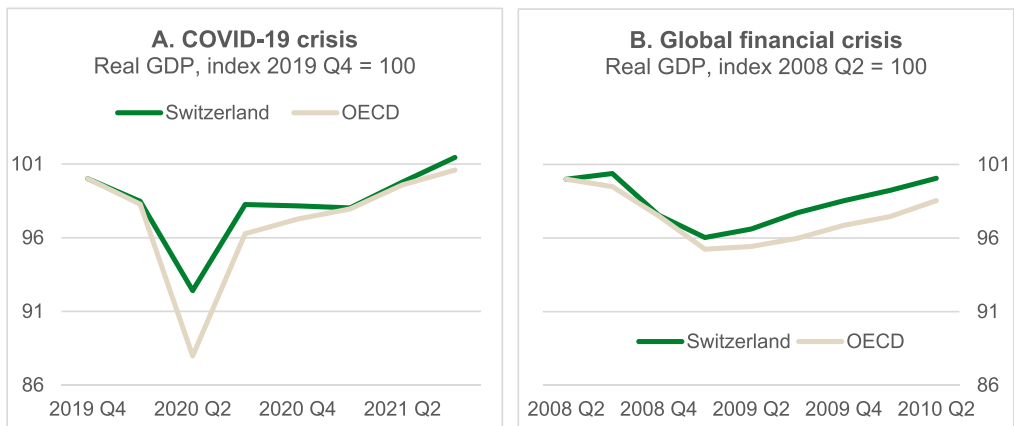


FIGURE 1 The Swiss economy has demonstrated its resilience in the face of a global crisis. *Source:* Organization for Economic Cooperation and Development (OECD) Economic Outlook database. *StatLink* <https://stat.link/zq6jva>.

consumption of goods and services, and disruptions in global supply chains. During the first quarter of 2020—a period of severe containment measures—the Swiss gross domestic product (GDP) fell by about 8%, fueling an eventual 2.5% GDP drop in 2020. However, the combination of the package of economic policies to support the economy in 2020, the lifting of restrictions the following year, and Switzerland's stable macroeconomic environment resulted in stronger resilience and faster recovery compared with other OECD countries (Figure 1).

Although the government played a central role in designing and implementing Switzerland's policy package, the ad hoc policy design during the crisis unavoidably resulted in moral hazard issues and capital allocation inefficiencies.¹ Importantly, grants in the form of direct transfers or government guarantees ultimately are paid by Swiss taxpayers and may lead to inflationary pressures.

This paper's objective is to analyze the design of explicit ex ante rules and instruments to build resilience to future pandemics. An ex-ante framework could be more efficient and less costly than ex-post financing that was implemented during 2020–2021.² For example, according to the United Nations Office for Disaster Risk Reduction, every dollar invested in risk reduction and prevention can save up to 15 US dollars in post-disaster recovery.³ Although further research is needed to provide a similar estimate for risk management of pandemics' economic impact, we would expect a similar trend in terms of benefits. The issue is relevant because pandemic frequency is expected to increase in the coming decades due to global trade, travel, and the growing intensity of interaction between humans and animals (Marani et al., 2021). By raising awareness, boosting preparedness, and reducing the financial burden, the ex ante framework can improve the Swiss economy's resilience to future shocks.

¹See, for example, Dishonest partial unemployment claims alarm Swiss auditors - SWI swissinfo.ch; Pandemic costs CHF 11 billion in temporary unemployment payments - SWI swissinfo.ch; Parliamentary group wants stricter checks on short-time work - SWI swissinfo.ch.

²See Kunreuther (2015) and OECD/The World Bank (2019) for the analysis of loss financing of extreme events.

³See our impact | UNDRR

The COVID-19 pandemic elicited a discussion in the academic and policy communities about the possibility of designing public–private partnerships (PPPs) that would implement risk-pooling and risk transfer, as well as improve resilience to future pandemics (ABI, 2021; Global Risks, 2021, 2023; Tetley, 2021; Government Actuary's Department, 2020). It also revealed that insurance's role in providing coverage for business interruptions caused by pathogens, either in Switzerland or worldwide, has been limited to food processing companies covering local and short-term events. As part of their business operations, food processing companies need to prevent pathogenic spread in their production systems. However, other firms, including restaurants, usually do not have insurance coverage for business interruptions caused by pathogens and related confinement measures taken by government authorities, leading to a few legal disputes in several countries (OECD, 2020).

We contribute to the debate by investigating the possibility to design an insurance-based scheme for pandemic risks in Switzerland. The country already has developed experience managing large natural hazard risks in the scope of the private Swiss Natural Hazards pool (ESP, for Elementarschaden-Pool) in six cantons⁴ and Liechtenstein, as well as mandatory building insurance with public cantonal building insurers in the other 19 cantons. Soon after the pandemic began, the working group, including the Swiss insurance industry, developed a proposal on possible pandemic insurance solutions, named Projekt “Pandemieversicherung,” in September 2020. However, after the Federal Council announced in April 2021 that it would not pursue recommendations in the report. As a consequence, it remains unclear whether and how the government intends to deal with major business interruptions risks that the private sector cannot insure in the future.

Building on the stock of knowledge of the COVID-19 shock's impact and policy measures' effects on firms in Switzerland and other economies, it is now possible to provide a new perspective on pandemic insurance possibilities. The COVID-19 shock's silver lining is the extensive data collection effort and empirical research on economic losses tied to the pandemic, as well as government policies' adequacy and impact. The data amassed during the pandemic provide an opportunity to evaluate and calibrate *ex ante* schemes for managing economic risks arising from pandemics in Switzerland. Our paper is a step in this direction.

Our focus is on non-damage business interruption insurance to alleviate hardships on businesses caused by the pandemic. It is distinct from existing Swiss practices of managing large natural hazard risks because the main cause of business revenue loss is business interruptions resulting from government-imposed lockdowns. However, we recognize that economic damages' severity is intertwined closely with healthcare responses' incentives, coordination, and financing, including the development and global distribution of vaccines, as discussed in Agarwal and Gopinath (2022). Furthermore, household demand for life insurance may have been impacted by COVID-19. Wang (2024) suggests increased awareness of mortality risk and financial security concerns in response to the pandemic. The analysis of the interaction between economic, healthcare and life insurance demand responses are beyond the scope of the paper, but they are important topics for future research.

The rest of this paper is organized as follows. Section 2 discusses the impact of policies that aimed to support Swiss firms during the COVID-19 pandemic. Section 3 assesses Swiss firms' revenue losses due to COVID-related business interruptions. Section 4 highlights how pandemic insurance could reduce firms' exposure to revenue shocks and lessen reliance on costly

⁴The six cantons are Appenzell Innerrhoden, Geneva, Obwalden, Schwyz, Uri, and Ticino.

interventions. Section 5 uses data from Switzerland's natural hazard pool to demonstrate how private companies pooling risks can implement risk diversification for natural perils. Section 6 discusses the feasibility of pandemic insurance PPPs, as well as issues that SECO raised in response to the pandemic insurance working group proposal in 2020. Section 7 concludes.

2 | ECONOMIC POLICY RESPONSE TO COVID-19 IN SWITZERLAND

The Swiss economy's overall performance in 2020–2021 masks the heterogeneity across sectors and population groups (see Figure 2). Service sectors such as hotels and catering contracted by 54%, in contrast to finance and insurance (part of “Other business sector services” category on Figure 2), which felt the least impact, contracting 2% (SECO, 2020). Furthermore, government restrictions and behavioral responses impacted the labor market significantly, and the crisis hit low-income households the hardest (OECD, 2022).

To support the economy during the shock, Switzerland in 2020 implemented a package of 45 large-scale policy measures varying across a spectrum of fiscal, monetary, prudential, and other policies (Figure 3). These measures included grants for partial unemployment compensation, financial aid to particularly affected firms, and compensation for canceled events. Also, the government extended a range of guarantees to financial and nonfinancial sectors to provide liquidity to small and medium-sized enterprises (SMEs), airlines, and airline maintenance services. Funding for lending (FFL) programs (Figure 3, panel a) allowed banks to access low-cost funding to lend to businesses. These programs varied significantly across countries in terms of the program size and usage, the maximum loan maturity available to firms, and the cost of funds to banks relative to benchmark rates (Casanova et al., 2021).

The prudential policies comprised the suspension of financial institutions' share buyback programs and the Swiss Financial Market Supervisory Authority's (FINMA) recommendation

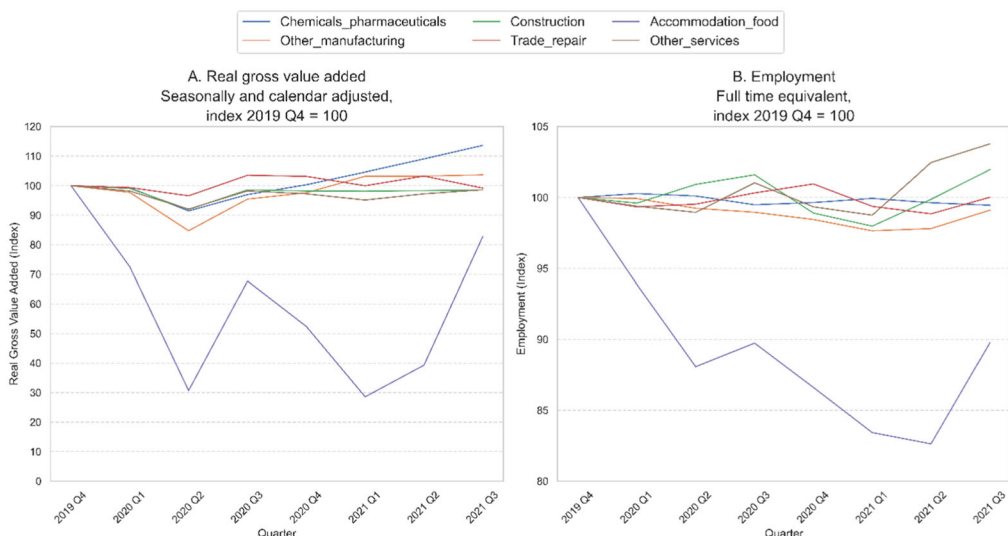
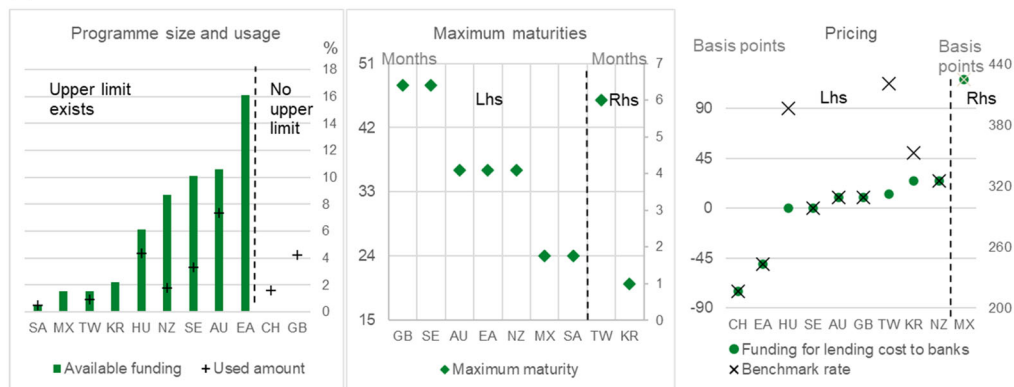


FIGURE 2 Overall resilience masks high heterogeneity across sectors and groups. *Source:* State Secretariat for Economic Affairs (SECO); Federal Statistical Office (FSO). *StatLink* <https://stat.link/zbm6rk>.

(a)



(b)

Type of Policy	Instrument	Applied in Switzerland
Labor related schemes	(Partial) redundancies	x
	Wage subsidies	x
	Self-employed	x
Deferral measures	Income / corporate Tax	
	VAT	
	Social security and pension	x
	Rent / utilities	x
	Debt moratorium	
Financial Instruments	Loan guarantees	x
	Direct lending to SMEs	x
	Grants and subsidies	x
	Equity Instruments	x
Structural Policies	New markets	x
	Teleworking / digitalisation	x
	Innovation	x
	Training and redeployment	
	Start-ups	x
	Sustainability measures	

FIGURE 3 Summary of policy interventions in Switzerland and comparison with other major economies. (a) Funding for lending terms, available funding, and use in Switzerland compared with other countries. Panel (a), the left panel reports program size and usage as a percentage of 2020 GDP. The middle panel reports maximum loan maturities in months, with two scales RhS (right-hand side) and Lhs (Left-and side) separated by the dashed line. The right panel reports the pricing of funding to banks, with two scales (RhS and Lhs) separated by the dashed line. Values may correspond to different points in time due to data availability. Used amount not available for EA, KR, and MX. Country abbreviations: Australia (AU), Euro area (EA), Hungary (HU), Korea (KR), Mexico (MX), New Zealand (NZ), Saudi Arabia (SA), Sweden (SE), Switzerland (CH), Chinese Taipei (TW), United Kingdom (GB). Benchmark rates: AU = Cash Rate Target, CH = SNB Policy Rate, EA = Deposit Facility, GB = BoE Base Rate, HU = Central Bank Base Rate, KR = BoK Base Rate, MX = Benchmark Policy Rate, NZ = Official Cash rate, SE = Riksbank Reference Rate, TW = Policy Rate. (b) SME and entrepreneurship policy instruments utilized in Switzerland during the COVID-19 pandemic. Panel (b) comprises the instruments utilized in Switzerland vs. the list of all SME and entrepreneurship instruments utilized in different countries during the February 2020–February 2021 period. *Source:* BIS; Casanova et al. (2021) and OECD.

to level dividend distributions for banks. Banks' countercyclical capital buffer was deactivated to give them more flexibility to grant credit. Together with the other major central banks, the Swiss National Bank (SNB) announced coordinated action to enhance the provision of global liquidity further via standing US dollar liquidity swap line arrangements, which are essential to the bank-funding market.⁵ We provide a comprehensive summary of these policies in Appendix A using a database developed by the International Monetary Fund (IMF), as described in Kirti et al. (2022).

Swiss firms were impacted by the pandemic shock through revenue and cost-of-funding channels. On one level, for many Swiss firms, COVID-19 caused significant turnover reductions arising from lockdown restrictions and supply-and-demand shocks. As a result, firms' revenue dropped while they incurred fixed and variable (including labor) costs. On another level, COVID-19 led to a sharp increase in firms' external financing costs. Due to the sharp increase in aggregate economic uncertainty, banks, and financial market investors were unwilling to extend credit to firms or provide liquidity. Furthermore, the crisis reduced firms' credit quality and their collateral values, thereby increasing external financing costs.

Several policies aimed to address hurdles that hindered firms' liquidity access during the crisis. Credit supply policies were designed to promote bank lending to firms by relaxing banks' capital constraints, such as the cancellation of countercyclical capital buffer requirements for banks. Firms' credit quality guarantees and borrowing capacity policies aimed to enable firms to overcome immediate liquidity needs due to lost revenue and to raise funding for new investments at reasonable costs. Both banks' willingness to lend and firms' ability to borrow are relevant to aggregate lending in the economy and the rate of bankruptcies; thus, these policies interacted as imperfect substitutes.

The COVID-19 shock's impact on liquidity and investment needs was heterogenous across firms. Some firms could not produce goods or provide services due to lockdown restrictions and supply chain disruptions, for example, hairdressing services and construction. Others needed capital for new investment to adapt to the COVID-19 environment, such as investing in e-commerce. Many firms were exposed to both effects to some degree, depending on their business models, that is, on one side, firms were experiencing sharp drops in revenue, effectively resulting in permanent income losses due to business interruptions. On the other side, firms faced difficulties meeting fixed costs and the pressing need for new investment to adopt their business models to the new circumstances.

2.1 | The COVID-19 emergency loan program in Switzerland

The COVID-19 emergency loan program was launched in Switzerland in March 2020 to provide guarantees to banks in response to firms' liquidity shortfalls. It was one of the largest policy efforts to provide companies with liquidity, but financing for new investment needs was explicitly excluded.

As Fuhrer et al. (2021) documented, the program was accessible to most firms based in Switzerland, except large firms with turnover exceeding CHF 500 million and firms founded after February 2020. A firm could apply for the loan through its bank for an amount up to 10%

⁵The other participating central banks included the Bank of Canada, Bank of England, Bank of Japan, European Central Bank, and US Federal Reserve.

of annual turnover, up to a maximum of CHF 20 million, with a maturity of 5 years. The government fully guaranteed the first loan tranche of up to CHF 500,000. Qualifying companies could also apply for the second tranche, 85% of which was guaranteed. Loan terms for the first (the second) tranche were 0% (0.5% for the guaranteed part).

2.2 | The COVID-19 emergency loan program's impact on firms

Brühlhart et al. (2020) conducted an early assessment of financial support utilization among small businesses in Switzerland during the COVID-19 pandemic in mid-April 2020. Using a survey of self-employed (SE) workers and SMEs, Brühlhart et al. (2020) found that lockdown restrictions were positively related to the use of the COVID-19 loan program. Fuhrer et al. (2021) use comprehensive firm-level data that combines the entire registry of commerce (Betriebs- und Unternehmensregister) and registry of all COVID-19 loans recorded by guaranteeing organizations (JANIS) during 2020. Fuhrer et al. (2021) report that 20% of Swiss firms participated in the program, which is substantial considering that about 60% of Swiss firms had no debt before the crisis. The program's volume was 2.4% of the Swiss annual GDP, comparable with the US loan guarantee program's volume of 2.5% of the US annual GDP (Baudino, 2020). Fuhrer et al. (2021) argue that the program reached target firms, that is, participation in the loan program was higher for firms with greater exposure to lockdown restrictions, weaker liquidity, younger age, and smaller size.

The emergency loans aimed to provide firms exclusively with liquidity support during the COVID-19 shock. In particular, firms were not allowed to use program loans to finance new investments—only replacement investments. The program aimed to smooth the impact of losses resulting from the COVID-19 shock and reduce the likelihood of bankruptcy, rather than facilitate firms' adaptation to the new environment. Eckert and Mikosch (2022) suggest that the program was successful in containing an increase in bankruptcy rates due to the COVID-19 shock, and bankruptcy rates in 2020 and the first half of 2021 in Switzerland actually were substantially lower than pre-COVID-19 rates.

Figure 4 reports the share of firms participating in the program under the General Classification of Economic Activities (NOGA) code.⁶ The accommodation and hotel services, motor vehicle sales and repairs, and construction sectors appear to be among the heaviest users of the loan program. One can observe that the firms experiencing revenue losses because of the COVID-19 shock participated in the program more intensively. Therefore, it is plausible that the program was used as compensation for permanent income losses, as well as for liquidity support.

2.3 | Efficacy issues with COVID-19 economic policies

Switzerland implemented a large and comprehensive package of economic policies to aid firms affected by COVID-19, contributing to its fast recovery (Kirti et al., 2023). Firms' permanent revenue losses were compensated partially by providing unemployment benefits, grants, and

⁶The General Classification of Economic Activities (NOGA) is a comprehensive classification system that categorizes all economic activities into a hierarchy of 794 positions at its most specific level. See <https://www.bfs.admin.ch/bfs/en/home/statistics/industry-services/nomenclatures/noga.assetdetail.22044305.html>.



FIGURE 4 Firm participation in the loan program by economic sector. *Source:* Federal Department of Economic Affairs, Education, and Research and own calculations.

guarantees to the most affected sectors, such as airlines, as well as by providing access to bank lending at subsidized costs through the loan program. Firms' liquidity access was implemented through the loan program and other macroprudential measures to stimulate bank lending. Firms' need for new investment was addressed by supporting banks' ability to lend to firms by easing banks' access to the SNB refinancing facility and reducing their regulatory capital requirements.

Although banks were crucial to providing firms with access to liquidity and subsidized funding, the analyses discussed above suggest that the loan program and fiscal support policies were also used to compensate firms for permanent revenue losses. While providing liquidity and funding to firms is at the core of banks' financial intermediation function, compensation for revenue losses caused by business interruptions lies beyond the scope of banks' business models. However, if scope for risk diversification exists, insurance can be added to the package of future pandemic policy responses. In the following section, we assess revenue losses by Swiss firms during the COVID-19 pandemic to illustrate revenue losses' relevance, despite policies implemented to support firms during the pandemic. We then develop a framework to illustrate how pandemic business interruption insurance would interact with other policies.

Further analysis is needed to assess the program's cost to Swiss taxpayers. Kaufmann (2020) provided early estimates of the loan program's impact on unemployment and found that around CHF 400,000 in loan volume is needed to save one job. Eventual costs depend on borrowers' default rates and on whether the job saving is permanent.

3 | FIRMS' REVENUE LOSSES DUE TO COVID-19 IN SWITZERLAND

Analyzing the cost and effectiveness of Switzerland's policy intervention during the COVID-19 pandemic is important to design policies to build resilience to future pandemics. We quantify the government intervention policies' efficacy by analyzing the relationship between firms'

revenue drops during the pandemic and COVID-19 incidence rates and government lockdown policies. Our analysis aims to quantify the residual exposure to pandemic shocks that firms experienced despite the implementation of government policies. The analysis also provides an initial assessment of the scope for pandemic insurance by documenting a substantial drop in firms' revenues driven by COVID-19 incidence rates and restrictions.

Our analysis combines three types of data in Switzerland: payment transaction data, COVID-19 incidence rates, and lockdown data. The payment transaction data is the proxy for firms' revenue losses caused by the pandemic and related social distancing restrictions and consumer responses. The data is obtained from the Monitoring Consumption Switzerland project (Brown et al., 2023) and comprise aggregated daily data on debit and credit card payments in Switzerland.⁷ Data as of January 2019 are available, with values scaled by the average daily turnover of all payment methods. Although payment volume cannot be expressed in monetary Swiss Franc terms, all data points are divided by the same scalar. Therefore, the scaled data are informative in terms of turnover's relative importance in different regions, merchant categories, and agglomeration types.

We focus on the economic sectors most affected by the COVID-19 pandemic—namely accommodation, food and beverage services, and transport services—as classified in the NOGA. Figure 5 presents monthly variations in payment card transactions in these merchant categories during the period from January 2019 to December 2022.

Daily COVID-19 incidence rate data is obtained from the Federal Office of Public Health, which collects data reported by the Swiss cantons and the Principality of Liechtenstein. The database includes daily incidence values over 100,000 inhabitants for the period from February 2020 to December 2022.

The data on the KOF Stringency-Plus Index (Pleninger et al., 2022) accounts for variations in COVID-19 containment restrictions' stringency in different cantons. The index is calculated based on the Oxford Stringency Index methodology (Hale et al., 2020) and is provided by the KOF Swiss Economic Institute.

We evaluate the relationship between payment card transactions, and COVID-19 incidence rates and the severity of restriction measures during the first COVID-19 wave, from mid-February until mid-June 2020. We assess cantonal government intervention's direct (Model 1) and indirect (Model 2) effects by estimating the following two models:

Model 1. Canton decisions' direct impact on the economy:

$$\text{Payment card transactions}_{i,t} = \beta_0 + \beta_1 \text{incidence rate}_{i,t-1} + \beta_2 \text{Stringency}_{i,t-1} + \varepsilon_{i,t}.$$

Model 2. Canton decisions' indirect impact on the economy:

$$\begin{aligned} \text{Payment card transactions}_{i,t} = & \beta_0 + \beta_1 \text{incidence rate}_{i,t-1} + \beta_2 \text{Stringency}_{i,t-1} + \beta_3 \\ & \text{incidence rate}_{i,t-1} \times \text{Stringency}_{i,t-1} + \varepsilon_{i,t}. \end{aligned}$$

⁷See Monitoring Consumption Switzerland and Brown et al. (2023). The data contain debit card payments at merchants in Switzerland by domestic and foreign cardholders, credit card payments in Switzerland by domestic and foreign cardholders, and by point of sale and e-commerce merchants, mobile payments at merchants in Switzerland, cash withdrawals by domestic debit cardholders, and cash deposits by domestic debt cardholders.

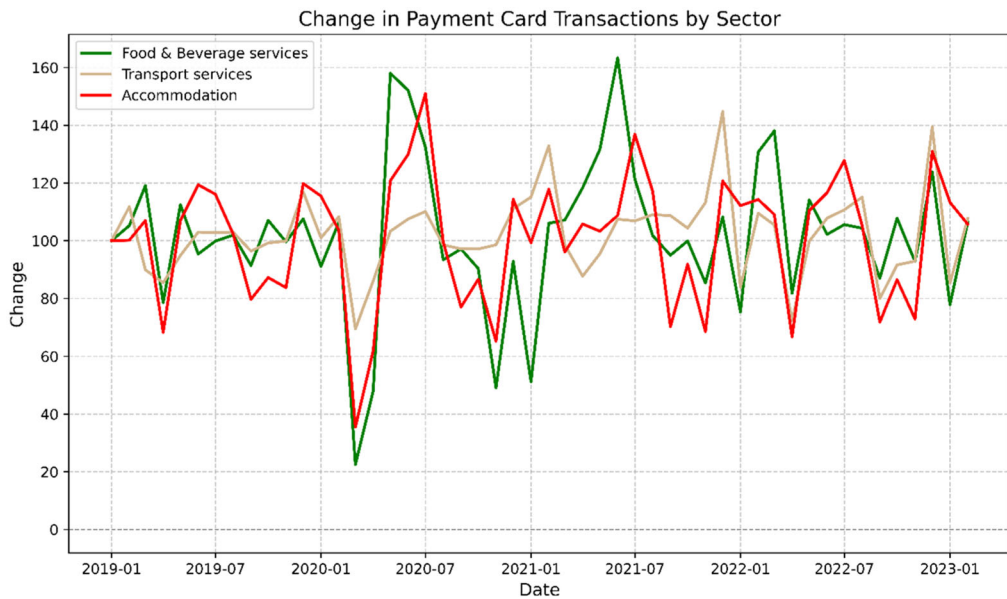


FIGURE 5 Variations in the amount of payment card transactions. This figure depicts the percentage changes in payment card transactions compared to the previous month. The reporting period depicted on the x-axis starts in January 2019 (2019-01) and reports the six-month intervals. The y-axis reports the percentage change, starting at 100 values in January 2019. *Source:* Monitoring Consumption <https://monitoringconsumption.com/> and own calculations.

In these models, i denotes the merchant category and t denotes the week during the sample period. We exploit the variation in incidence rates between regions to estimate higher incidence rates' impact on payment card transactions' contraction, which proxies for revenue losses.

We assess the role of the severity of restriction measures introduced in each canton using KOF Stringency-Plus Index data (Pleninger et al., 2022). In line with Ashraf (2020) and Pleninger et al. (2022), government-imposed restrictions can exert direct and indirect effects on economic variables. As for direct effects, social distancing measures reduce economic activity, eliciting a negative effect. However, these measures can also enhance investors' confidence and increase their expectations of an economic recovery due to lower disease rates, eliciting a positive effect. As for indirect measures, strong measures can weaken the infection's intensity, thereby weakening forward-looking economic variables' negative reaction to the infection's growth.

The results presented in Table 1 indicate government-imposed restrictions' role in the drop in firms' revenues. We find that higher COVID-19 incidence rates exerted a significant, negative effect on firms' revenues in all three sectors. The negative relationship between weekly payment card transactions and weekly COVID-19 incidence rates is particularly pronounced for food and beverage services, both in magnitude and statistical significance. These results suggest that firms in accommodation, food and beverages services, and transport services have experienced significant revenue losses in areas with high incidence rates. Notably, the use of payment transactions is a suitable proxy for firms' revenues in these sectors, as their revenues derive mainly from the provision of in-person services. In Model 1, the negative and significant estimated coefficient of the stringency index indicates that firms' revenues also suffered from the restrictions.

TABLE 1 Payment card transactions by sector and incidence rate and stringency index during the first COVID-19 wave in Switzerland.

Dependent variable: Payment card transactions						
Model	Model 1			Model 2		
	Accommodation	Food and Beverage Services	Transport Services	Accommodation	Food and Beverage Services	Transport Services
Incidence Rate Coefficient	−0.006***	−0.015***	−0.001	−0.040***	−0.068**	−0.016***
Incidence Rate Std. Error	0.002	0.004	0.001	0.014	0.03	0.006
Stringency Coefficient	−0.025***	−0.027***	−0.011***	−0.030***	−0.035***	−0.013***
Stringency Std. Error	0.004	0.009	0.002	0.005	0.01	0.002
Incidence x Stringency Coefficient				0.0005**	0.001*	0.0002***
Incidence x Stringency Std. Error				0.0002	0.0004	0.0001
Constant Coefficient	2.500***	3.821***	0.951***	2.805***	4.297***	1.085***
Constant Std. Error	0.278	0.578	0.112	0.298	0.629	0.12
Observations	98	98	98	98	98	98
R ²	0.342	0.218	0.328	0.381	0.244	0.374
Adjusted R ²	0.328	0.201	0.313	0.362	0.220	0.354
Residual Std. Error	0.910	1.895	0.368	0.887	1.873	0.357
Degree of Freedom	95	95	95	94	94	94
F Statistic	24.714***	13.239***	23.143***	19.320***	10.124***	18.749***
Degree of Freedom	2; 95	2; 95	2; 95	3; 94	3; 94	3; 94

Note: This table presents estimates of changes in weekly payment card transactions for the three merchant categories—accommodation, food and beverage services, and transport services—using COVID-19 infection cases and the weekly average KOF Stringency-Plus Index, as well as their interaction term. The estimates are for the first COVID-19 wave in Switzerland, which comprises data from mid-February until mid-June 2020. *, **, and *** refer to statistical significance at the 10%, 5%, and 1% levels, respectively.

In Model 2, the positive, albeit statistically nonsignificant, values associated with the interaction term show that the economic decline in regions subject to more stringent government restrictions is mitigated partly by social-distancing measures' indirect effect on incidence rates. The statistically significant and negative coefficient of the stringency index in Model 2's estimates implies that restrictions exerted a first-order effect on the reduction of firms' revenues. Simultaneously, the statistically nonsignificant coefficients of incidence rate and the estimation term indicate that the relationship from the interaction between incidence rate, restrictions, and economic variables can be more nuanced than specified in Model 2. For example, Pleninger et al. (2022) found that containment measures' stringency led to both fewer transactions and infection rates, by estimating a vector autoregressive model to evaluate feedback effects between credit card transactions, restriction measures' stringency, and infection rates.

We have also explored the relationship between *the changes* of the payment transactions and incidence rates and restriction measures. The results are reported in Appendix B. The results are consistent with the results of the analysis in terms of levels, particularly regarding the impact of the stringency of restrictions. However, the changes in the incidence rate and the interaction terms in Model 2 become less significant.

Overall, the analysis of the relationship between economic activity, proxied by payment card transactions in different sectors, and COVID-19 incidence rate and social distancing measures' stringency confirms that firms' revenue losses were the result of policy measures' stringency and rising infection rates. Therefore, despite the package of policies used to support Swiss firms, the firms were exposed to the risk of permanent revenue loss. Our results are consistent with Chetty et al. (2024) regarding the impact of infection rates on US firms' revenues. Chetty et al. (2024) also document that firms most hit by the COVID-19 shock experienced a permanent loss in revenues; thus, the fiscal policies could not restore the impact of the shock on employment.

The analyses indicate that permanent revenue loss due to business interruption is a significant risk to firms during the pandemic. Furthermore, this permanent revenue risk cannot be mitigated by providing liquidity support and guarantees, or by providing fiscal support for employment. Managing the risk of permanent revenue loss requires an insurance solution. In the following section, we present a simple framework that explains how pandemic insurance reduces firms' exposure to such shocks. Furthermore, we discuss how the policy interacts with monetary and macroprudential policies.

4 | SCOPE FOR BUSINESS INTERRUPTION INSURANCE DURING PANDEMICS

We argue that pandemic insurance can mitigate the permanent revenue losses faced by firms during a pandemic while simultaneously reducing the costs associated with other forms of government intervention, such as liquidity provision and fiscal support. In this section, we explain how the pandemic shock impacts firms' revenue losses, liquidity needs, and investment requirements, and how these can be addressed through pandemic insurance.

The economic impact of a pandemic on firms can be divided into three key components. First, the pandemic generates a negative revenue shock. Second, after containment measures are implemented, firms require additional liquidity and capital to cover fixed costs and adapt their business models to new circumstances. Third, heightened economic uncertainty during the pandemic drives up the cost of external capital, further straining firms' finances.

If a firm has purchased pandemic insurance before the pandemic, it receives an indemnity payment when the shock occurs. This insurance payment strengthens the firm's balance sheet, offsets revenue losses, and mitigates the overall impact of the shock.

From the firm's perspective, pandemic insurance serves two critical purposes. First, by reducing the pandemic's adverse effects on revenues, it decreases the firm's liquidity and capital requirements, helping it avoid financial distress. Second, it enhances the value of the firm's pledgeable collateral, making it easier to raise external capital and reducing the total funding needed during the crisis.

In contrast, central bank interventions, such as FFL programs, provide banks with access to low-cost funding, incentivizing them to lend to firms. These programs target banks and their borrowers by reducing funding costs and have proven effective in preventing a credit crunch during the COVID-19 pandemic (Casanova et al., 2021). However, FFL programs come with both direct and indirect costs.

Direct costs include increased government and corporate debt, inflationary pressures, and long-term negative effects on productivity due to capital misallocation (Bergant & Forbes, 2023; Kirti et al., 2023). Indirectly, prolonged guarantees can encourage moral hazard, with banks lending to nonviable, over-indebted firms, risking “zombification” and the evergreening of guaranteed loans (Borio & Restoy, 2020). Conversely, withdrawing guarantees too early may trigger a wave of firm defaults (Juselius & Tarashev, 2021). Furthermore, such programs require robust bank supervision to ensure banks can absorb additional losses during the withdrawal phase (Drehmann et al., 2020).

Pandemic insurance offers a viable substitute for FFL programs, reducing the need for extensive central bank intervention. By lowering the likelihood of financial distress, reducing firms' capital requirements, and increasing the value of pledgeable collateral, pandemic insurance mitigates the economic impact of a shock. Consequently, it can reduce the scale of FFL programs required to support the corporate sector. This, in turn, minimizes the risks of moral hazard and capital misallocation, easing inflationary pressures associated with expansionary monetary policies.

In summary, we emphasize the interrelationship between pandemic insurance and the fiscal and monetary policy measures employed during the COVID-19 crisis. Recent studies have examined the composition of policy packages implemented during the pandemic. As noted by Kirti et al. (2023), these policies were often introduced in combination, highlighting the importance of evaluating their efficacy jointly. Bergant and Forbes (2023) suggest there is potential for better integration of macroprudential tools with fiscal and monetary policies. Separately, researchers and the insurance industry have explored the use of catastrophe bonds with pandemic triggers (Kong, 2021; Medders & Schwarcz, 2022; OECD, 2021; Qiu, 2020; Schmitt & Spaeter, 2023).

In our view, pandemic insurance should be considered an integral part of pandemic crisis policy packages, alongside fiscal and monetary interventions, to enhance their overall effectiveness.

5 | THE STRUCTURE OF THE NATURAL HAZARD POOL IN SWITZERLAND

Building a market for pandemic insurance presents several challenges. Private insurers face significant obstacles, including limited geographic diversification and high accumulation risks during pandemic events (Gründl et al., 2021). Additionally, creating sufficient insurance

capacity may require mandating insurance purchases, similar to how household or auto insurance operates. These factors influence the price at which private insurers are willing to provide coverage and determine the extent of the government's role in facilitating a pandemic insurance market. To address these challenges, it is instructive to examine institutional arrangements already tested for other large risks, such as natural catastrophes.

Switzerland has extensive experience managing natural hazard risks through the Swiss Elemental Pool (Elementarschaden Pool, or ES Pool), a private insurance pool. This section provides the institutional background of the ES Pool, evaluates its risk-bearing capacity, and examines price markups using confidential data.

5.1 | Institutional background of the natural hazard pool

The Swiss natural hazard insurance system, established in 1953, covers perils such as flooding, storms, hail, avalanches, rockfall, and landslides. Since 1993, coverage for natural hazards has been mandatorily bundled with fire insurance. Private insurers underwriting fire-related risks for contents and buildings are required to provide natural hazard coverage at flat-rate premiums (Schweizerischer Versicherungsverband SVV, 2021).

The Swiss natural hazard pool operates on the principle of universal protection, offering affordable coverage against the material consequences of natural hazards (SVV, 2021). Its foundation is the double solidarity principle: solidarity among policyholders and solidarity among insurers.

Premium rates, deductibles, and coverage rules are legally defined (AVO Art. 175, 2005; Versicherungsaufsichtsgesetz, VAG, 2004) or regulated by FINMA (FINMA, 2013). The ES Pool does not maintain reserves but distributes losses across its 12 member insurers, who collectively cover over 90% of damages caused by natural perils. In cantons without cantonal building insurance (Kantonale Gebäudeversicherung), the pool covers building risks.

Natural hazard insurance applies to three main categories: household contents, other contents, and buildings, whether for private, industrial, or agricultural use. Premium rates are standardized across cantons, and insured perils include flooding, storm winds, hail, landslides, and snow pressure. Appendix C.1 provides a summary of premiums, deductibles, liability limits, and excluded perils.

Eighty percent of all losses from natural hazards are mutualized through joint reinsurance, while insurers retain 20% of losses. Insurers collect premiums, underwrite policies, and purchase joint reinsurance proportional to market share. When a natural hazard occurs, damage assessments account for reinsurance coverage, deductibles, and partial payment quotas, with final compensation determined based on market share.

5.2 | Natural hazard pool data

We rely on three datasets provided by the Swiss Elemental Pool to conduct the analysis:

1. Sums insured and number of policies data: This data set includes the total sum insured and the number of policies, disaggregated by postal code across Switzerland and Liechtenstein, as of March 31, 2022. The data are further broken down by type of insured item (buildings and contents) and usage (private, industrial/business, or agricultural). The relative sum

insured is also provided for each category. The limitation of these data is that the information is available only for 1 year, 2021.

2. **Loss Data:** This data set comprises an annual time series of total paid insured losses from 1980 to 2021, disaggregated by canton. Losses are categorized by nine natural perils (e.g., flooding, hail, and storms) and six types of insured exposure (contents or buildings, with private, industrial/business, or agricultural use). Loss amounts are inflation-adjusted based on Swiss annual inflation rates. This data set enables a granular analysis of historical losses by peril and usage type.
3. **Pool Development Data:** This data set contains annual data from 2001 to 2021 on the total sum insured, total premiums collected, total paid losses, and reserves. It provides a longitudinal view of the pool's growth and financial performance over two decades. However, the granularity of these data is on national level rather than cantonal level like the previous two datasets.

These datasets reveal key trends and regional variations in losses. For example, flooding and inundation account for the largest aggregate losses in most cantons, with exceptions such as Appenzell InnerRhoden and Liechtenstein (storm winds) and Geneva and Schwyz (hail). Figures 6 and 7 illustrate these historical patterns, showing flooding as the dominant peril, followed by storm winds and hail.

Losses by insured item type show that “Other Contents” (industrial and business contents) typically account for the largest payouts, with the highest loss observed in 2005. By contrast, the smallest losses occur in the Agricultural Building category. Figure 8 provides a detailed breakdown of losses by insured item category.

Figure 9 highlights trends in the total sum insured from 2001 to 2021. The “Buildings” category experienced the steepest growth, while “Household Contents” also showed a positive trend. In contrast, “Business/Industry Contents” displayed no consistent growth during this period. Appendix C.2 includes descriptive statistics of losses by natural peril and insured item category.

5.3 | The ES pools' risk-bearing capacity and markups

To evaluate the risk-bearing capacity and pricing structure of the Swiss Elemental Pool (ES Pool), we adopt the methodology proposed by Gründl et al. (2021). Specifically, we analyze the relationship between price markups and the tail characteristics of loss distributions, using detailed data on losses and premiums provided by the ES Pool. Our focus is on two insured item categories—Buildings and Others—to assess the pool's ability to manage catastrophic risks and ensure equitable pricing.

5.3.1 | Modeling loss distributions

We model the distribution of natural catastrophe losses for each insured item category (Buildings and Others) using historical loss data from 1980 to 2021. The data are adjusted for Swiss inflation rates and are disaggregated at the cantonal level. Losses are further categorized by peril type, including flooding, storm winds, hail, and avalanches.

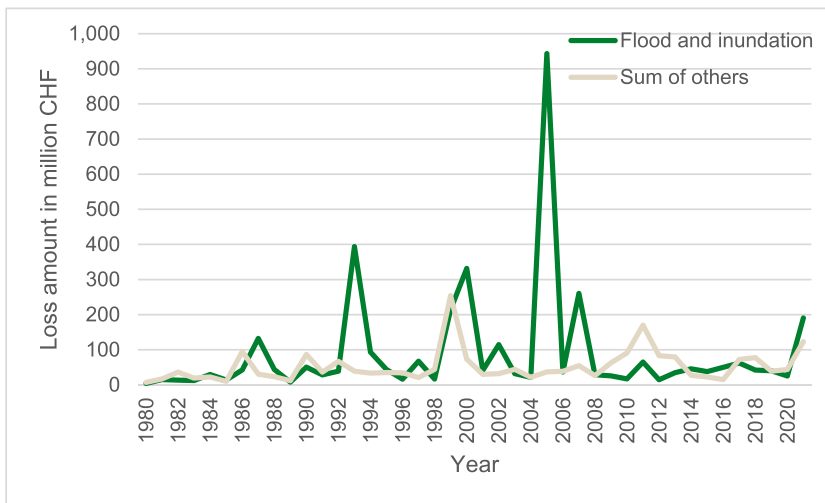


FIGURE 6 Historical natural hazard losses from 1980 to 2021. The amounts of annual losses paid by natural hazard pools for flooding and inundation are presented and compared with the sum of losses due to other perils. *Source:* Swiss Insurance Association and own calculations.

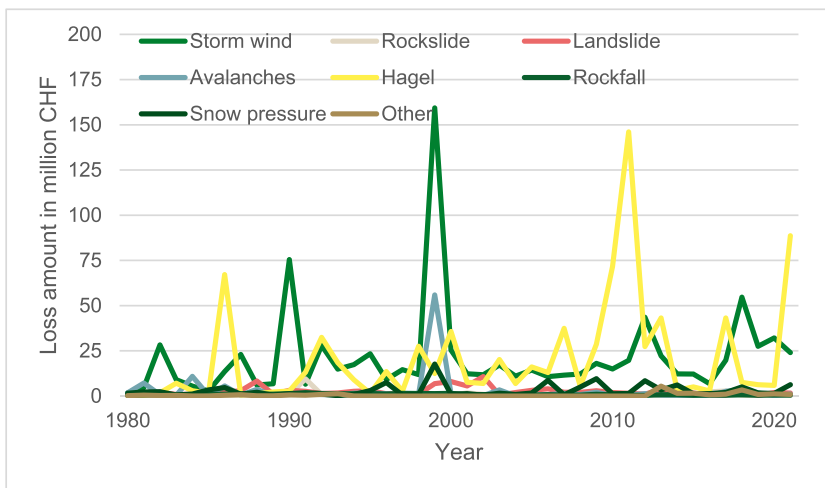


FIGURE 7 Historical natural hazard losses from 1980 to 2021. Annual losses per type of peril are presented (excluding flooding and inundation). *Source:* Swiss Insurance Association and own calculations.

Two key risk metrics are calculated for each canton and insured item category, using data set 2 as described in Section 5.2:

1. Expected Shortfall at 1%: This metric represents the average loss in the worst 1% of scenarios and captures the extreme tail risk of catastrophic events.
2. Volatility of the Loss Distribution: This measures the overall variability in losses, providing insight into the predictability and uncertainty of claims.

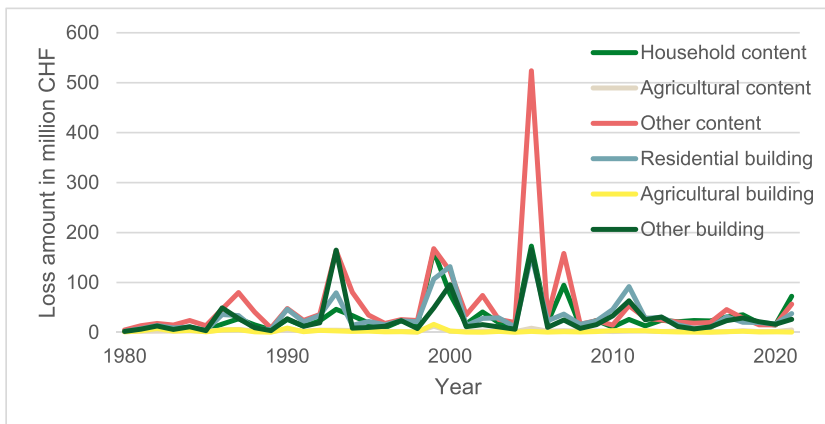


FIGURE 8 Historical natural hazard losses from 1980 to 2021 per type of insured item. *Source:* Swiss Insurance Association and own calculations.

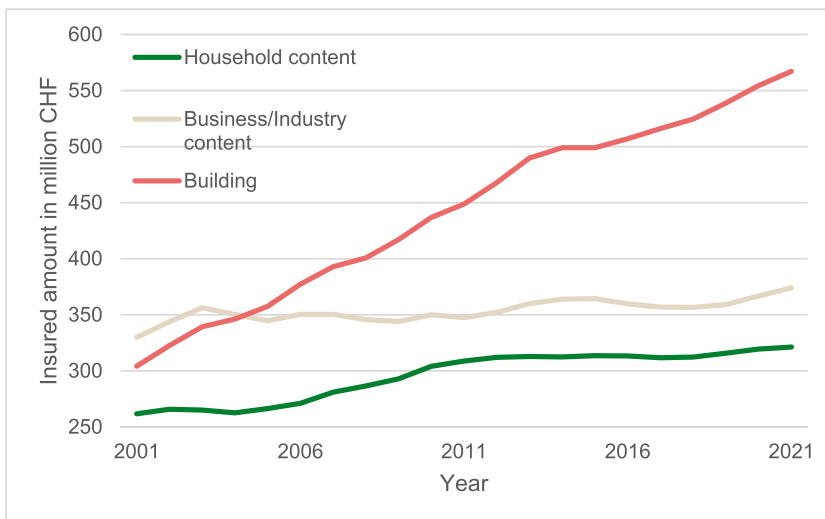


FIGURE 9 Historical insured losses from 2001 to 2021 per type of insured item. *Source:* Swiss Insurance Association and own calculations.

The loss distribution functions for each canton and peril type are fitted and evaluated using goodness-of-fit tests to ensure robust modeling. Detailed results of the loss distribution parameters and risk metrics are presented in Appendix C.3.

5.3.2 | Calculating price markups

The price markup is defined as the ratio of premiums collected to losses paid. Using 2021 data of data set 1, we calculate the markup for each canton and insured item category. This involves dividing the total premiums collected for a specific category by the total losses paid at the same level of granularity.

We estimate the relationship between the calculated price markups and the tail characteristics of the loss distributions using the following regression model:

$$\text{Price markup}_{i,t} = \beta_0 + \beta_1 \text{Expected shortfall at } 1\%_{i,t} + \varepsilon_{i,t}$$

in which i represents the canton, and t denotes the year. For robustness, we also test alternative specifications using volatility as the risk measure and logarithmic transformations of the variables to account for potential nonlinear relationships. The results are reported in Appendix C.4.

5.3.3 | Regression results

The regression results are presented in Table 2. For both insured item categories, Buildings, and Others, the relationship between price markups and tail characteristics is not statistically significant. The expected shortfall has a slightly positive coefficient for Buildings and a negative coefficient for Others, but neither achieves statistical significance.

Alternative specifications using volatility instead of expected shortfall yield similar results. The alternative specification results are reported in Appendix C.4. These findings, while constrained by the small sample size (25 cantons and Liechtenstein), suggest that price markups do not strongly correlate with tail risks. This outcome aligns with the solidarity principle of the ES Pool, which emphasizes equitable risk-sharing among member insurers.

5.3.4 | Observations on risk-bearing capacity

The ES Pool demonstrates the effectiveness of mutualization in managing catastrophic risks. By pooling resources and losses, the pool enables insurers to provide coverage for natural hazards

TABLE 2 Effect of the characteristics of the tail of the distribution on the markup for the two categories: Buildings and Others.

	Dependent variable	
	Markup: Buildings	Markup: Others
Expected shortfall at 1%	0.023 (0.165)	-0.175 (0.124)
Constant	19.840* (9.842)	23.274 *** (6.005)
Observations	26	27
R^2	0.001	0.074
Adjusted R^2	-0.041	0.036
Residual Std. Error (df = 24)	44.940	22.258
F Statistic (df = 1; 24)	0.019	1.985

Note: This table presents estimates of changes in markup for the two categories, Buildings and Others, given the expected shortfall at 1%. *, **, and *** refer to statistical significance at the 10%, 5%, and 1% levels, respectively.

at relatively low premiums. The 80% mutualization requirement ensures that most losses are distributed across the pool, reducing financial burdens on individual insurers. The remaining 20% of losses retained by insurers incentivizes prudent underwriting and risk management.

The joint reinsurance mechanism likely enhances cost efficiency. By purchasing reinsurance collectively, the pool benefits from economies of scale, potentially reducing overall reinsurance premiums. Although we cannot confirm this empirically due to data limitations, the structure of the pool suggests that this mechanism plays a critical role in maintaining financial sustainability.

In summary, the Swiss Elemental Pool provides a compelling example of how mutualization can effectively manage large-scale risks. While certain principles of the ES Pool, such as joint reinsurance and solidarity, may inform the development of pandemic insurance, the lack of geographic diversification remains a significant hurdle. Further innovation will be required to adapt these principles to the unique challenges of pandemic risk.

6 | DESIGNING A PPP FOR PANDEMIC RISKS

In this section, we analyze the feasibility of creating a pandemic insurance PPP, building on the insights from earlier sections of this paper. We begin by examining the challenges of private insurance for disaster risks, including pandemics, as discussed in Section 5, particularly the limitations of geographic diversification and the systemic nature of pandemic risks. We then review government compensation and financial assistance arrangements for managing disaster exposures, drawing on the fiscal and monetary policy interventions outlined in Section 2 and their limitations in addressing residual revenue risks highlighted in Section 3. Next, we summarize the proposal to organize a pandemic risk pool developed by the Swiss pandemic insurance working group in 2020 (Eidgenössische Finanzdepartement (EFD), 2020). This proposal has been critiqued by SECO and other commentators, who raised three primary concerns: the inefficiency of pandemic insurance due to a lack of diversification, the opportunity cost of reserves and government guarantees, and the financial and administrative burden of mandatory pandemic insurance participation for Swiss firms. We address these concerns in turn, using the analysis of policy complementarities in Section 4 and the lessons from mutualization in the Swiss Elemental Pool (Section 5) to present arguments supporting further evaluation of the costs and benefits of a pandemic insurance PPP, as well as the risks of inaction. Finally, we conclude the section by outlining a work plan for assessing the feasibility of a pandemic insurance PPP in Switzerland.

6.1 | Challenges of private insurance for disaster risk

The sustainability of the private insurance for disaster risks, such as natural catastrophes and man-made disasters, can be challenging. The literature on catastrophe insurance supply (Cummins et al., 2002; Cummins, 2006; Froot, 1999, 2001, 2007, 2008; Froot and O'Connell, 2008; Froot & Posner, 2000; Jaffee & Russell, 1997; Niehaus, 2002) discusses insurability limits of disaster risk, i.e., a risk with low frequency and high severity. Asymmetric information, agency problems, and capital market imperfections are the main reasons for constraining the private insurance industry's ability to share and transfer catastrophe risks to the financial

market. These imperfections result in high insurance premiums and limited equity capital capacity (Winter, 1994).

Ambiguity in assessing catastrophe risks (Charpentier, 2008; Gollier, 1997; Kunreuther & Michel-Kerjan, 2011) is another hurdle to the provision of private insurance for disaster risk. Policyholders' bounded rationality in assessing the impact of low frequency and high severity events impacts insurance demand by increasing demand's elasticity to price, income, and wealth (Grace et al., 2004), and by distorting risk mitigation incentives (Kunreuther et al., 2013; Kunreuther et al., 2019).

Pandemic risk has several additional features, including accumulation risk, i.e., the risk that all losses occur during the same period of a pandemic outbreak, covariance between pandemic business interruption losses and equity market performance, and the interrelation between pandemic business interruption losses and other insured losses (Hartwig et al., 2020; Klein & Weston, 2020; Richter & Wilson, 2020). Gründl et al. (2021) build a model that explicitly incorporates these features in investors' preferences and policyholder demand to assess their effect on equilibrium insurance prices.

Gründl et al. (2021) analyze the scope for the private market for pandemic insurance using US natural catastrophe insurance market data, as well as high-frequency data tracking the economic impact of the COVID-19 pandemic in the US. Gründl et al. (2021) developed a model and empirical tests to evaluate the price markup at which a private insurance market is willing to provide pandemic insurance. Gründl et al. (2021) then compare the price of a hypothetical pandemic insurance contract to the equilibrium prices observed in the US natural catastrophe insurance market. The main finding from the analysis is that the pandemic insurance price markup corresponds to the top 20% markup observed in the natural catastrophe insurance market. Therefore, although some scope exists for the private insurance market for pandemic risk insurance, it is limited.

Although Gründl et al.'s (2021) study could not be replicated for the Swiss economy due to data availability issues, it is plausible that the main finding about the limits to private insurance for pandemic risk would sustain. In the Swiss context, accumulation risk and interdependencies that constrain the private insurance market are reinforced further by the lack of geographic diversification and the Swiss economy's smaller size compared with the US.

As we discussed in Section 4, the economic impact of pandemics is systemic, with losses concentrated during the crisis and strongly correlated across firms and sectors. The lack of cross-sectional diversification increases premiums, making private insurance infeasible without government involvement. Gründl et al. (2021) emphasized that such risks require intertemporal diversification, which could be implemented through a PPP framework that pools premiums over time. This solution is particularly relevant given our earlier finding (Section 3) that Swiss firms experienced permanent revenue losses that could not be addressed by existing liquidity support or fiscal compensation measures.

6.2 | Government disaster risk financing overview

The government can enhance loss absorption capacity for disaster risks where private insurance market capacity is lacking or private insurance is not feasible at an affordable price (Jarzabkowski et al., 2018; OECD, 2015). The government can provide ex post loss financing by reallocating existing budgetary resources and raising post-disaster debt and taxation. Such measures allow the government to spread disaster costs across different sectors in the economy and across

generations. However, government capacity for ex post financing depends on many factors, including its current debt levels, fiscal position, flexibility to reallocate budgets and adjust fiscal parameters, diversification of its revenue sources, access to international aid and multilateral financing, and the ability to raise external financing amid the disaster at favorable costs that depend on its credit rating at the macroeconomic level (OECD, 2015). The implicit form of ex post fiscal stimulus that governments actively used during COVID-19 comprised “below-the-line” measures, such as loans, equity, and credit guarantees (Bergant & Forbes, 2023; Fuhrer et al., 2021). Using data on policy responses to COVID-19 in advance economics, Bergant and Forbes (2023) document that almost all countries announced a large fiscal stimulus, averaging about 11% of GDP, with below-the-line measures accounting for half the fiscal support.

Governments can also employ ex ante financing tools to prepare for future disasters, alone or in collaboration with the private insurance industry. These tools include building government reserves dedicated to disasters, contingent credit arrangements with financial institutions and international organizations, and insurance and catastrophe bonds and catastrophe-linked securities (OECD, 2015). These ex ante tools have been used in PPPs to promote specific risks' insurability by the private insurance industry. The government's involvement is often limited to collaboration in disaster risk assessment and specific mitigation investments for risk reduction. However, these tools are also used to establish a government-sponsored entity that assumes the role of reinsurer to private insurers on a stop-loss basis and can act as a counterparty for catastrophe bonds and other contingent financing (Eggleton & Gürses, 2023). Most PPPs—in which the private insurance industry and government partner in providing insurance and reinsurance, are used to promote insurability of specific risks, such as floods and earthquakes. Floods and earthquakes typically have regional scope and, thus, can be diversified cross-sectionally. A distinct aspect of the pandemic is that the accumulation risk limits the scope for cross-sectional risk diversification. Therefore, the ex ante solution for pandemic risk PPPs would require intertemporal risk diversification.

The COVID-19 crisis highlighted the limitations of ex post government interventions in managing business interruptions caused by pandemics. As analyzed in Section 2, the Swiss government implemented an extensive package of fiscal and monetary measures, which provided essential liquidity and reduced bankruptcies but could not prevent significant permanent revenue losses (Section 3). Moreover, these policies carried high economic costs, including increased public debt and inflationary pressures, which we discussed in Section 4.

The design of ex ante PPPs offers important advantages compared with ex post government support. Explicit and well-defined ex ante rules and processes provide clarity that supports the private initiative for risk reduction and reduces charity hazards from post-disaster aid. Insurers' claim management for insured losses reduces the scope of uncertainty amid the crisis. Also, an ex ante PPP reduces the need for ex post fiscal assistance. However, the effective design of ex ante PPPs requires the political will to avoid operational inefficiencies, undercapitalization, and market distortions (Cummins, 2006; Jaffee & Russell, 1997).

6.3 | The Swiss pandemic insurance working group's ex ante PPP proposal

The Secretariat for International Financial Matters established the Swiss pandemic insurance working group in collaboration with Swiss insurance industry representatives (Eidgenössische Finanzdepartement (EFD), 2020) in April 2020 to evaluate the pandemic insurance solution's

feasibility in Switzerland. The organizational forms discussed in the proposal include two structures, claims pooling and a capital accumulation pool, which can also differ depending on whether the government is compensated for its guarantee. These proposals build on the principles of risk sharing observed in the Swiss Elemental Pool (Section 5). However, as SECO noted, both proposals face significant challenges that require further evaluation.

6.3.1 | Claims pooling proposal

The first organizational form involves a simple pooling of claims. The claims pooling structure entails neither reserves nor provisions. The federal government assumes most risks, with the insurance industry assuming only limited risk exposure. The insurance industry would purchase reinsurance centrally for the pool.

Under the claims pooling proposal, no reserves or provisions are accumulated in years when no pandemic event occurs, and participating insurers could change from year to year. This structure raises questions regarding the use of premiums paid and the adequate amount of the premium in years when no claims are filed. Furthermore, because no accumulation occurs in years with no pandemic event, one cannot ensure that the federal government does not use the funds to invest in pandemic precautions instead of other expenditures, or that the insurance industry is collecting funds to prefinance the next pandemic. Finally, no capital buildup occurs, so a potentially longer pandemic-free period does not lead to premium reductions.

The claims pooling proposal is similar to the ESP structure (Eidgenössische Finanzdepartement (EFD), 2020). Thus, one can build on the ESP-positive experience in operating such a pool. However, this structure cannot address the main difference between natural hazard risk and pandemic risk, that is, the lack of geographic diversification in the case of pandemics and the lower frequency of pandemics compared with natural hazards.

6.3.2 | Capital accumulation pool proposal

The second proposed structure is a capital accumulation pool. This form involves the establishment of a separate entity either as a nonprofit insurance cooperative or as a special vehicle set up by the government. The capital pool allows for capital accumulation over time and, therefore, creates substantial equalization provisions paid out in the event of a pandemic.

The main difference compared with a claims pool is that it offers intertemporal diversification. This approach is consistent with the need for long-term risk sharing discussed in Section 4. However, it requires a more complex organizational form. During the first years, the capital pool could result in higher premiums for policyholders, who can be compensated through premium adjustments as capital accumulates over time. Some legal challenges need to be addressed regarding the structure's specific form, investment strategy, etc., but the capital pool offers a visible form for pre-financing the next pandemic.

6.3.3 | Views on the federal government's role

The claims pool proposal suggests distributing risk assumption in such a way that the federal government bears most of the risk, while the insurance industry bears some risk. Two possible

forms of this structure are discussed based on whether the federal government is compensated for risk-taking. The form in which the federal government does not receive a risk premium would result in a lower premium for pandemic risk policyholders, but would constitute a systematic burden to the federal government. Moreover, when the federal government is not compensated for the risk assumption, companies receive subsidized pandemic risk protection and, thus, would not be fully internalizing their costs.

Two possibilities of the capital pooling structure are discussed. The first involves the creation of a cooperative in which both the federal government and insurance industry contribute to the capital pooling and take stakes in risk assumption. The second entails capital pooling with accumulation only by the federal government. While the latter structure could result in lower surcharges in the first few years, thereby allowing for lower premiums, it would offer less flexibility over time in adapting premiums. Furthermore, while capital pooling does offer some clear advantages in creating pre-financing means for future pandemics, the second variant proposed does not leave space for the insurance industry to help bear pandemic risk, although some insurance firms in Switzerland may be able to bear some exposure to pandemic risks.

6.4 | Discussion of issues raised about the pandemic insurance proposal

In response to the Swiss pandemic insurance proposal, SECO and other commentators mainly have raised three issues. The first issue is that the accumulation of risk during the pandemic implies that insurance is not an efficient solution to manage pandemic risk because it cannot achieve risk diversification. The second issue is that pandemics are too rare; thus, it would take too long to receive benefits from a pandemic insurance PPP. The third issue is that imposing mandatory participation in pandemic insurance incurs unnecessary administrative and financial burdens on Swiss firms, particularly those unable to adjust quickly to government restrictions during COVID-19. In this section, we discuss each of these issues in more detail.

6.4.1 | Issue1: Pandemic risk is not diversifiable cross-sectionally

The lack of cross-sectional diversification of pandemic risk implies that the PPP solution needs to involve intertemporal risk sharing. Gründl et al. (2021) consider an intertemporal risk-sharing mechanism that facilitates pandemic risk-pooling in which all insurers participate in the pool during a 50-year period, with a long-term intermediary, such as a government, facilitating risk sharing. The setting is analogous to an Arrow-Debreu complete market environment and estimates the first-best potential of risk sharing by the private insurance industry. In this setting, Gründl et al. (2021) find that the expected shortfall of a hypothetical insurance contract loss distribution is reduced by 50%. This result is obtained for the risk-pooling within the private insurance industry. The PPP, with the possibility of external risk transfer in the form of reinsurance or a capital market solution, can increase the pandemic risk insurance scope further.

The concept of intertemporal risk sharing is used in other forms of financial intermediation. Holmström and Tirole (1998) analyze the need for government supply and active management of liquidity, finding that in a situation of aggregate uncertainty, the private sector cannot satisfy its liquidity needs. The government can improve welfare by issuing bonds that commit to future

consumer income, effectively creating an intertemporal risk sharing mechanism that complements the private provision of liquidity by firms issuing new claims and holding claims on other firms. The main reason is that private sector allocation of liquidity is suboptimal in the presence of systematic risk. Macprudential capital requirements for banks in the form of countercyclical capital buffers are another form of intertemporal risk sharing, in which capital is accumulated during the business cycle and is employed to absorb losses during downturns. Finally, pension plans often embedding mechanisms for intergenerational transfers among different cohorts of policyholders to share contemporaneous variations in portfolio stock market returns.

6.4.2 | Issue 2: Pandemic risk is too rare; thus, it should not be insured

The argument is that because pandemic risk is rare, creating PPP pandemic insurance has no value because its benefits would be available only far in the future, while its costs are immediate. The argument contains several elements. Due to climate change and intensifying interactions between humans and animals, the risk of pandemics is likely to increase over time. Furthermore, the economic theory of decision-making under uncertainty suggests that a rational decision-maker will be willing to pay a positive mark-up against the loss of a rare event with a large loss, such as a pandemic. In relative terms, the rational decision maker will be willing to tolerate a higher insurance mark up for low probability/large loss events than for relatively significant probability/low losses events. We explain the theoretical arguments further in Appendix D. In practice, as discussed in Section 6.1, previous literature has found that the decision-makers exhibit behavioral biases that often result in underinsurance for large risks.

Considering that losses are rare, the insurance premium required to cover the risk margin and the pandemic insurance's administrative expenses should be low in actuarial terms, making it affordable. Furthermore, the rare nature of pandemic events provides scope to transfer the risk to long-term-horizon investors, such as pension funds and sovereign wealth funds at affordable prices. Finally, the other benefit of the ex ante solution is that it reduces economic uncertainty, thereby improving the Swiss economy's economic resilience and consequently reducing the cost of capital to Swiss firms.

6.4.3 | Issue 3: Mandatory participation creates an unnecessary financial burden for unaffected firms

Mandatory participation by all Swiss firms is essential for the financial sustainability of the pandemic insurance PPP, building on the principle of solidarity central to the Swiss Elemental Pool (Section 5). Without mandatory participation, there would be significant risks of adverse selection, free-riding, and charity hazards. Our justification for mandatory participation draws on the discussion in Section 4, which highlights the interrelationship between ex ante pandemic risk insurance and the ex post fiscal and monetary policies required during a pandemic. As Section 4 demonstrates, these ex post policies impose fiscal burdens and inflationary pressure costs that are borne by all current—and potentially future—firms. Requiring all firms to contribute to an ex ante insurance pool ensures that these costs are equitably distributed, reducing reliance on costly ex post interventions. This approach aligns with the solidarity

principle and promotes fairness across the economy while mitigating the financial risks of future pandemics.

6.5 | Data-driven analysis of pandemic insurance's economic merits

The conceptual arguments for developing a pandemic insurance PPP highlight the need for further empirical research on its merits, building on the insights from earlier sections. As outlined in Section 3, detailed data on firms' revenue losses, liquidity needs, and post-pandemic recovery can inform the PPP's design. This research entails three stages. First, the scope for pandemic insurance should be evaluated by analyzing Swiss firms' utilization of the loan program for liquidity and revenue loss compensation, as well as their post-COVID-19 performance, using a comprehensive firm-level data set such as that constructed by Fuhrer et al. (2021). Second, as demonstrated in Section 4, the tradeoffs between fiscal and monetary policy packages during the crisis and their impact on the economy in subsequent years should be examined within a macroeconomic modeling framework. Finally, such a structural macroeconomic model could be extended to simulate counterfactual scenarios with pandemic insurance PPPs, enabling an assessment of the welfare implications of ex ante insurance and its potential to reduce the reliance on costly ex post interventions. These steps offer a pathway for future research to evaluate the feasibility and effectiveness of a pandemic insurance PPP.

6.6 | Policy recommendations to build resilience to pandemic risk

The COVID-19 pandemic exposed significant vulnerabilities in the financial and economic systems of many countries. While governments implemented various measures to mitigate economic disruption, the effectiveness of these policies varied widely. One of the key recommendations from our analysis is the introduction of a pandemic insurance mechanism, which would enhance financial preparedness and complement other policy responses. By ensuring financial continuity through insurance, governments and businesses can free up fiscal and monetary capacity to support broader economic stabilization efforts. This approach aligns with international experiences, where countries with stronger risk-sharing mechanisms were better able to sustain economic activity. The increasing complexity and interconnectedness of global risks, as highlighted by Global Risks, (2021, 2023), underscore the need for innovative solutions, such as pandemic insurance, to help governments and businesses manage systemic shocks effectively.

A key lesson from the crisis is the need for well-structured fiscal support that is timely, well-targeted, and automatically activated during pandemics. Research by Chetty et al. (2023) highlights that while stimulus payments boosted spending early in the crisis, their effectiveness declined over time, particularly for higher income households. To enhance future resilience, governments should establish automatic fiscal stabilizers, such as pre-designed wage subsidies and business relief programs, to ensure rapid and equitable economic support. Additionally, targeted measures for vulnerable groups, such as small businesses and low-wage workers, can prevent long-term scarring effects on employment and income levels.

Ensuring financial sector stability and continued credit flow is another critical policy priority. Casanova et al. (2021) illustrates that loan guarantees and funding-for-lending programs helped sustain bank lending and supported business continuity during the pandemic.

Countries should build on these lessons by maintaining countercyclical capital buffers that can be released during crises, expanding government-backed credit guarantees for SMEs, and allowing for regulatory flexibility in loan classifications. These measures would ensure that businesses retain access to credit, preventing liquidity crises that could amplify economic downturns. Pandemic insurance, as proposed in our paper, would further enhance financial stability by reducing the burden on banks and enabling targeted credit support where it is most needed.

A coordinated policy response is essential for maximizing the effectiveness of fiscal, monetary, and prudential measures. Kirti et al. (2023) suggests that countries implementing integrated policy packages experienced stronger economic recoveries. Future frameworks should ensure that fiscal stimulus measures are aligned with monetary interventions, central banks are equipped with targeted liquidity support tools, and prudential regulators adapt oversight requirements to economic conditions.

Finally, institutionalizing pandemic preparedness frameworks would enhance long-term resilience to future crises. Real-time economic monitoring, as demonstrated in the Chetty et al. (2024) study, could guide policymakers in designing better targeted interventions. A pandemic insurance mechanism would complement these efforts by providing a structured risk-sharing approach, reducing the fiscal burden, and ensuring that financial resources remain available for broader economic stabilization. By adopting these recommendations, countries can build a more resilient economic system that is better prepared for future health crises.

7 | CONCLUSIONS

In this paper, we examine the scope for pandemic insurance in Switzerland and highlight the residual exposure of Swiss firms to revenue losses despite the implementation of a comprehensive package of fiscal and monetary policies during the COVID-19 pandemic. As detailed in Section 3, these policies provided critical liquidity and fiscal support but failed to fully offset the revenue drops caused by business interruptions from government-imposed restrictions. In Section 4, we highlight how firms' exposure to negative revenue shocks—and the need for costly fiscal and monetary interventions—could have been reduced if pandemic risk insurance had been in place.

In Section 5, we analyze the structure and performance of the Swiss Elemental Pool (ESP), which successfully diversifies natural catastrophe risk through risk-pooling and mutualization. Building on these insights, we explore the feasibility of designing a pandemic insurance PPP in subsequent sections, noting the unique challenges of pandemic risks. As discussed in Section 6, the global and systemic nature of pandemics limits cross-sectional diversification, but we argue that intertemporal risk sharing, combined with capital accumulation and the transfer of residual risks to reinsurance and financial markets, offers a feasible path forward.

We conclude that a pandemic insurance PPP is conceptually viable, but its practical implementation depends on a thorough empirical evaluation of its economic costs and benefits. Specifically, as discussed throughout Sections 3 and 4, further research is needed to assess its interrelation with fiscal and monetary policies, its impact on firms' financial resilience, and the design of sustainable risk-sharing mechanisms. By addressing these challenges, a pandemic insurance PPP could play a vital role in improving the economy's preparedness for future pandemics.

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DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available from the Swiss Insurance Association. Restrictions apply to the availability of these data, which were used under license for this study.

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APPENDIX A: ECONOMIC POLICIES IMPLEMENTED IN SWITZERLAND DURING COVID-19

See Table A1.

TABLE A1 Key policy responses to COVID-19 in Switzerland as of July 1, 2021.

Type of intervention	Announcement date	Instrument
Fiscal (federal level)	March 13, 2020	- Up to CHF 8 billion for partial unemployment compensation; - CHF 1 billion for financial aid to particularly affected firms; - CHF 580 million for loan guarantees for SMEs; - Loss compensation for cancelled events.
	March 20, 2020	- Extension of short-time work allowances and simplification of the application process; - A guarantee program of up to CHF 20 billion to help bridge loans to SMEs (details); - Temporary, interest-free deferral of social-security contribution payments for affected companies; - Extended payment periods for taxes and payables to federal suppliers without incurring interest on arrears;- Compensation for loss of earnings for self-employed (SE) workers and for some employees affected by official measures to combat COVID-19 (e.g., parents who need to take care of children due to school closings).
	March 25, 2020	- Additional measures of around CHF 600 million per month.
	April 03, 2020	- Doubled the size of the loan guarantee program to CHF 40 billion.
	April 8-16, 2020	- The short-time work program was expanded twice to cover on-call workers and more SE workers, respectively.
Type of intervention	Announcement date	Instrument
Fiscal (federal level)	April 22, 2020	- Extended loss compensation for SE to May 16, even if they reopened their businesses on an earlier date; - Expanded loan guarantee program for startups.
	April 29, 2020	- CHF 1.9 billion credit support to airlines and aviation-related businesses; - Take-up of bridge loans under the federal guarantee program, which expired on July 31.
	July 01, 2020	- Provide additional financing to public transport and rail freight companies;

TABLE A1 (Continued)

Type of intervention	Announcement date	Instrument
		- Extend revenue compensation for SE workers to mid-September; - Extend the maximum period for receiving short-time work compensation from 12 months to 18 months; - Scale back COVID-related financial support to international sports organizations; - Legislate a new law to regulate the bridge loan guarantee program beyond the national emergency period.
	August 12, 2020	- CHF 400 million in financial support to air traffic control company; - Legal standstill for travel agencies; - Simplified regulations for unemployment insurance until the end of 2020.
	October 14, 2020	- Extension of support to the cultural sector until the end of 2021.
	November 04, 2020	- Issued guidelines for government loans to support professional and semi-professional sports clubs; - Extended short-time work scheme coverage for employees on demand and compensation for income losses for SE workers until June 31, 2021.

Type of intervention	Announcement date	Instrument
Fiscal (federal level)	November 11, 2020	- Increased credit for procurement of COVID-19 vaccines; - Renewed measures in the area of occupational benefits; - Extended transitional supports to the media; - Launched a stimulus program, "Innovation Switzerland," to help companies maintain their innovative strength during the pandemic.
	November 18, 2020	- Proposals for additional COVID-19 support measures, including joint hardship support programs with cantons, wider coverage of the short-time work scheme, and grants for professional and semi-professional sports clubs.
	November 25, 2020	- Adoption of the COVID-19 Hardship Assistance Ordinance, a joint effort with cantonal governments to support viable firms that suffered severe losses during the COVID-19 pandemic.
	December 11, 2020	- Ask Parliament for more flexibility regarding eligibility to receive hardship support and propose

(Continues)

TABLE A1 (Continued)

Type of intervention	Announcement date	Instrument
		expanding this program's total size from CHF 1 billion to CHF 2.5 billion.
	December 18, 2020	- Adjusted the hardship ordinance further, lowering the turnover threshold for support from CHF 100,000 to CHF 50,000, allowing qualifying companies to receive double subsidies while imposing a tighter ban on dividends; - Reduced the income loss requirement for SE workers to receive compensation; - Increased support for the cultural sector; - Loosened or extended already-loosened regulations on short-time work programs further.
	January 13, 2021	- Loosened eligibility criteria and conditionality for the hardship support program; - Increased the limit on support that a firm could receive.
	January 20, 2021	- Adjusted rules on the short-time work scheme to extend and expand its coverage.
	January 27, 2021	- Financed the short-time work program for 2021; - Doubled the size of the hardship support program to CHF 5 billion; - Provided additional costs for COVID-19 tests; - Extended maximum unemployment benefit coverage by three months.
Type of intervention	Announcement date	Instrument
Fiscal (federal level)	February 17, 2021	- Increased the hardship support program's size from CHF 5 billion to CHF 10 billion, including CHF 3 billion dedicated to help larger firms previously not covered by the program; - Added CHF 940 million to compensate for income losses for SE workers.
	March 31, 2021	- Added another CHF 1.3 billion in COVID-related spending, mainly to cover additional costs for testing, but also with small amounts dedicated to helping tourist traffic and civil defense operations; - Adjusted several COVID-related laws, including the hardship ordinance, ordinance on loss of earnings, and the Team Sports Ordinance, with most changes intended to provide more support to the economy and to clarify these programs' conditions.
	April 28, 2021	- CHF 226 million for the global initiative "Access to COVID-19 Tools Accelerator," making Switzerland's total contribution CHF 300 million;

TABLE A1 (Continued)

Type of intervention	Announcement date	Instrument
	May 2021	- CHF 150 million on medicine; - CHF 148 million on measures for the cultural sector; - CHF 90 million on the event industry. - Extension of compensation for loss of earnings until the end of 2021; - Abolition of the upper limit for grant support to team sports; - Increase in the maximum period for drawing the short-time work allowance to 24 months; - Launch of a three-pillar strategy (normalization, support for structural change, and revitalization) to guide the transition of economic policies as the epidemiological situation improves.
	June 2021	- Simplified procedures for short-term work support, with eligibility for those in fixed-term employment relationships, apprentices, and employees on call in open-ended employment relationships extended until end-September; - Subsidies for print media were extended until the end of 2021; - Limits increased for hardship support to heavily affected companies.
Type of intervention	Announcement date	Instrument
Fiscal (federal level)	June 30, 2021	Extended support to Skyguide by allocating additional funds for 2022.
Monetary and macro-financial	March 18, 2020	- Debt enforcement standstill from March 19 to April 4; - The Swiss National Bank (SNB) activated a U.S. dollar liquidity swap line with the U.S. Federal Reserve; - The SNB lowered the interest rate, offered a new 84-day maturity, and increased seven-day maturity operations' frequency from weekly to daily (reduced to three times per week since July 1 and to once a week since September 1).
	March 19, 2020	- The SNB announced that starting April 1, the threshold factor for exempting sight deposits from negative interest rates would be raised from 25 to 30.
	March 25, 2020	- The SNB introduced a new COVID-19 refinancing facility that would operate in conjunction with the federal government's guarantees for corporate loans, allowing banks to obtain liquidity from the SNB. This facility subsequently was revised to

(Continues)

TABLE A1 (Continued)

Type of intervention	Announcement date	Instrument
		allow use of loans guaranteed by cantons as collateral.
	March 27, 2020	- The FC approved SNB's request for deactivation of the countercyclical capital buffer.
	May 19, 2020	- The Swiss Financial Market Supervisory Authority (FINMA) introduced a temporary exclusion of deposits held at central banks from the calculation of banks' leverage ratio (extended from May 19, 2020 to January 1, 2021). FINMA emphasized that the capital released from this relaxation should be used to support liquidity provision and is not to be distributed as dividends or other similar distributions related to 2019.
	July 01, 2020	- The SNB adjusted the rate calculation for its liquidity-shortage financing facility, effectively lowering borrowing costs from this facility.
Type of intervention	Announcement date	Instrument
Monetary and macro-financial	April 23, 2021	- The SNB decided to discontinue offering dollar liquidity at the 84-day maturity starting from July 1, 2021.
Exchange rate and balance of payments	2020	- The SNB has increased its interventions in the FX market to limit appreciation of the Swiss franc and bought the equivalent of CHF 110 billion in 2020.
	Q1 2021	- The SNB interventions declined in Q1 2021, totaling CHF 296 million.
	2020–2021	- Sight deposits held at the SNB have increased by around CHF 123 billion (or 17.5% of 2020 GDP) since early February 2020, a proxy for the total amount of Swiss franc liquidity injected through FX interventions, repo operations, and the COVID-19 refinancing facility.

Source: IMF, Policy Responses to COVID-19 ([imf.org](https://www.imf.org)).

APPENDIX B: RELATIONSHIP BETWEEN CHANGES IN PAYMENT CARD TRANSACTIONS AND THE INCIDENCE RATE AND STRINGENCY OF RESTRICTION INDEX

See Table B1.

TABLE B1 Relationship between changes in payment card transactions and the incidence rate and stringency index.

Dependent variable: Δ Payment card transactions						
Model	Model 1			Model 2		
	Accommodation	Food and Beverage Services	Transport Services	Accommodation	Food and Beverage Services	Transport Services
Δ Incidence Rate Coefficient	0.001	-0.001	-0.001	-0.001	-0.0002	-0.002*
Δ Incidence Rate Std. Error	0.003	0.004	0.001	0.003	0.005	0.001
Δ Stringency Coefficient	-0.055***	-0.084***	-0.015***	-0.059***	-0.081***	-0.017***
Δ Stringency Std. Error	0.007	0.011	0.003	0.008	0.013	0.004
Δ Incidence x Δ Stringency Coefficient				0.0002	-0.0001	0.0001
Δ Incidence x Δ Stringency Std. Error				0.0002	0.0003	0.0001
Constant Coefficient	0.039	0.236**	-0.026	0.031	0.242**	-0.029
Constant Std. Error	0.06	0.097	0.027	0.060	0.099	0.027
Observations	98	98	98	98	98	98
R^2	0.511	0.508	0.35	0.515	0.509	0.357
Adjusted R^2	0.500	0.497	0.336	0.500	0.493	0.337
Residual Std. Error	0.530	0.864	0.240	0.530	0.868	0.240
Degree of Freedom	95	95	95	94	94	94
F Statistic	49.564***	49.017***	25.530***	33.321***	32.473***	17.422***
Degree of Freedom	2; 95	2; 95	2; 95	3; 94	3; 94	3; 94

Note: This table presents estimates of changes in weekly payment card transactions for the three merchant categories—accommodation, food and beverage services, and transport services—using Δ COVID-19 infection cases and the Δ weekly average KOF Stringency-Plus Index. The estimates are for the first COVID-19 wave in Switzerland, which comprises data from mid-February until mid-June 2020. *, **, and *** refer to statistical significance at the 10%, 5%, and 1% levels, respectively.

APPENDIX C: ES POOL ANALYSIS

1. Natural hazard pool detailed characteristics

See Table C1.

See Table C2.

See Table C3.

TABLE C1 Summary of cantonal obligations toward the natural hazard insurance pool and cantonal building insurance.

Buildings	Household content
➤ Among seven cantons (GUSTAVO) and Lichtenstein: is mandatory in UR, SZ, OW, and Lichtenstein. is not mandatory in AI, GE, TI, and versus Exception: In the district of Oberegg in AI, there is mandatory insurance with the building insurance of the district. ➤ In the other 19 cantons, KGV provides mandatory building insurance.	➤ In all cantons except NW and VD, private household content insurance is not mandatory in all cantons except FR and JU, where it is mandatory. Exception: In NW and VD, where content insurance is mandatory, cantonal building insurance provides coverage.

Note: List of canton abbreviations: AI, Appenzel Innerrhoden; GE, Genève; NW, Nidwalden; OW, Obwalden; SZ, Schwyz; TI, Ticino; UR, Uri; VD, Vaud; VS, Wallis. KGV = Kantonale Gebäudeversicherungen, which stands for the cantonal level public sector building insurers.

TABLE C2 Summary of current premiums, deductibles, and liability limitations of the natural hazards insurance pool.

Item	Premium rate	Deductibles	Liability limitations
- Household content (Hausrat)	0.21‰ 0.35‰ 0.31‰	- Household content: Fr. 500 - Agricultural inventory: 10% of indemnity, min. Fr. 1000, max. Fr. 10,000 - Other content: 10% of indemnity, min. Fr. 2500, max. Fr. 50,000 - Residential and agricultural buildings: 10% of indemnity, min. Fr. 1000, max. Fr. 10,000 - Other buildings: 10% of indemnity, min. Fr. 2500, max. Fr. 50,000	- Market limit 1 Bn per event in total each for Other and Building content - Individual limit per policyholder Fr 25 million each for Other and Building content
- Other content (übrige Fahrhabe)			
- Building (Gebäude)		The deductible is per event for chattels, with building insurance deducted once each. If an event affects several buildings owned by a policyholder, a deductible is provided for each one—at least CHF 2500, with a maximum of 50,000 francs.	

TABLE C3 Summary of items exempt from compulsory insurance and hazards, excluding those uninsured by the ES pool.

Items exempt from compulsory insurance	- Easily relocatable buildings (e.g., exhibition and festival huts, large tents, carousels, show and exhibition booths, air domes, and diamond halls), as well as their contents. - Caravans, mobile homes, boats, and aircraft, including accessories. - Motor vehicles in warehouses outdoors or under a canopy. - Mountain railways, cable cars, ski lifts, overhead electrical lines, and masts (excluding local area networks). - Items on construction sites (“construction site” applies to the whole area containing material assets that are related to a structure, even in front of it beginning and after its termination). - Greenhouses, hotbed windows, and plants. - Nuclear installations within the meaning of Article 3, Letter d, of the Nuclear Energy Act of March 21, 2003.
Excluded hazards	- Snow pressure damage only to bricks or other roofing materials, chimneys, gutters, or drainpipes. - Storm and water damage to ships and boats on the water. - Damage caused by vibrations - Tremors caused by tectonic processes triggered in the Earth’s crust (earthquake) and volcanic eruptions
Noninsured hazards	- Damage caused by subsidence, poor subsoil, faulty structural design, inadequate building maintenance, omission of defensive measures, artificial Earth movements, snow slides from roofs, groundwater, and rising/overflowing water bodies (experience has demonstrated that these are shorter or repeated at longer intervals). - Damage that occurs, regardless of its cause, due to water from reservoirs or other artificial water systems, water backed up from sewers, or alteration the atomic structure. - Operational and management damage, which should be expected, based on experience, such as damage from building construction and civil engineering, tunnel construction, and mining stones, gravel, sand or clay.

2. Descriptive statistics on ES pool loss data

See Table C4.

See Table C5.

3. Fitted distributions on ES pool loss data

See Table C6.

See Table C7.

See Table C8.

See Table C9.

TABLE C4 Summary statistics on ES pool loss data from natural peril (historical data from 1980 to 2021).

	Mean	SD	CV (SD/Mean)	Min	Max	Count
Flooding and inundation	98,186,802	169,055,719	1.72	7,589,193	979,735,500	42
Storm winds	24,199,462	29,164,176	1.21	3,132,634	175,301,774	42
Rockslides	987,336	1,794,717	1.82	133,129	11,781,215	42
Landslides	2,911,297	2,649,483	0.91	357,304	11,877,906	42
Avalanches	3,480,149	9,733,175	2.80	43,151	61,508,224	42
Hail	21,832,318	30,105,551	1.38	696,914	144,847,407	42
Rockfall	1,050,168	503,074	0.48	349,051	2,345,264	42
Snow pressure	3,336,249	3,619,217	1.08	248,691	19,452,058	42
Other	605,040	1,021,982	1.69	-	5,464,721	42
Total	156,588,820	181,288,991	1.16	20,574,989	1,018,135,294	42

TABLE C5 Summary statistics on ES pool loss data by insured item (historical data from 1980 to 2021).

	Mean	SD	CV (SD/Mean)	Min	Max	Count
Household content	32,839,840	38,667,818	1.18	4,473,657	172,991,269	42
Agricultural content	3,185,003	2,261,623	0.71	795,577	12,736,018	42
Other content	56,307,014	84,964,154	1.51	6,595,130	520,205,424	42
Residential building	33,390,894	33,724,287	1.01	2,936,360	152,320,156	42
Agricultural building	2,953,242	3,222,333	1.09	463,683	16,463,268	42
Other building	27,912,828	37,522,395	1.34	2,639,895	180,264,780	42
Total	156,588,820	181,288,991	1.16	20,574,989	1,018,135,294	42

4. Alternative specifications of the relationship between markup and risk characteristics of the loss distribution in the ES pool

We estimate a relationship between the computed price markup and tail characteristics. These regressions are conducted separately for the Buildings and Others categories.

1. $\ln(\text{Price markup}_{i,t}) = \beta_0 + \beta_1 \ln(1\% \text{expected shortfall}_{i,t}) + \varepsilon_{i,t}$
2. $\text{Price markup}_{i,t} = \beta_0 + \beta_1 \text{volatility}_{i,t} + \varepsilon_{i,t}$
3. $\ln(\text{Price markup}_{i,t}) = \beta_0 + \beta_1 \ln(\text{volatility}_{i,t}) + \varepsilon_{i,t}$

See Table C10.

See Table C11.

See Table C12.

TABLE C6 Natural hazard loss distribution estimates by type of natural peril.

Natural hazard	Weibull parameters			LN parameters			Gamma parameters		
	p1	p2	KS test	p1	p2	KS test	p1	p2	KS test
Floods and inundation	0.844	87.263	0.214	3.918	1.023	0.155	0.877	0.009	0.252
Storm winds	1.138	25.637	0.164	2.848	0.746	0.110	1.623	0.067	0.176
Rockslides	0.956	0.960	0.189	−0.480	0.799	0.104	1.210	1.226	0.202
Landslides	1.268	3.164	0.129	0.752	0.796	0.095	1.729	0.594	0.121
Avalanches	0.645	2.173	0.164	0.052	1.396	0.098	0.527	0.152	0.233
Hail	0.804	19.056	0.103	2.287	1.325	0.065	0.752	0.034	0.127
Rockfall	2.286	1.191	0.159	−0.071	0.500	0.144	4.339	4.131	0.140
Snow pressure	1.078	3.448	0.189	0.764	0.932	0.157	1.274	0.382	0.206
Total	1.113	164.318	0.165	4.679	0.797	0.141	1.478	0.009	0.190

Note: This table presents the statistics on fitted distributions using natural hazard losses from the natural hazard pool in Switzerland during the 1980–2021 period by type of natural hazard. For the analysis, the losses are rescaled (divided by 1,000,000). Due to a lack of data, the natural hazard category “Other” is removed from the analysis.

TABLE C7 Natural hazard loss distribution estimates by SBH code.

Natural hazard	Weibull parameters			LN parameters			Gamma parameters		
	p1	p2	KS test	p1	p2	KS test	p1	p2	KS test
Household Content	1.081	34.049	0.193	3.089	0.826	0.139	1.387	0.042	0.209
Agricultural Content	1.614	3.595	0.158	0.988	0.550	0.103	3.092	0.971	0.126
Other Content	0.965	55.178	0.186	3.538	0.876	0.151	1.152	0.021	0.220
Residential Building	1.156	35.397	0.166	3.011	0.923	0.136	1.464	0.044	0.142
Agricultural Building	1.105	3.085	0.137	0.678	0.869	0.087	1.376	0.466	0.150
Other Building	0.971	27.474	0.129	2.817	0.947	0.090	1.114	0.040	0.149
Total	1.113	164.318	0.165	4.679	0.797	0.141	1.478	0.009	0.190

Note: This table presents the statistics on distributions fitted using natural hazard losses from the natural hazard pool in Switzerland during the 1980–2021 period by SBH code. For the analysis, losses are rescaled (divided by 1,000,000).

TABLE C8 Loss distribution tail characteristics.

	Household content	Agricultural content	Other content	Residential building	Agricultural building	Other building	Total
1% expected shortfall	206	12	370	236	21	220	931
Volatility	0.823	0.551	0.876	0.861	0.869	0.947	0.797

Note: This table presents loss distribution tail characteristics by SBH code. In the first line, it is reported the 1% expected shortfall of the loss distribution and in the latter, volatility is provided.

TABLE C9 Tail characteristics of the distribution of paid losses per insured item category and canton.

Canton	1% ES: Building	1% ES: Other	Volatility: Building	Volatility: Other
AG	5	113	1.851	1.342
AI	5	2	1.149	0.954
AR	1	21	1.365	1.362
BE	6	135	1.464	1.080
BL	3	25	1.930	1.198
BS	3	5	2.083	1.029
BU	0	0	0.686	0.971
CA	0	0	1.076	1.497
FL	12	2	1.199	1.017
FR	5	21	1.360	1.008
GE	54	19	1.348	1.222
GL	7	4	1.819	1.124
GR	3	25	1.792	1.086
JU	1	15	1.305	1.200
LU	6	88	1.507	1.242
NE	1	18	1.433	1.190
NW	6	6	2.091	2.072
OW	52	18	1.342	1.433
SG	2	30	1.166	0.799
SH	1	6	1.753	1.288
SO	0	20	1.114	1.028
SZ	240	63	1.376	1.334
TG	1	34	1.518	1.180
TI	117	52	0.894	1.002
UR	31	16	1.178	1.335
VD	2	2	1.491	0.985
VS	120	84	1.090	1.304
ZG	1	33	1.512	1.501
ZH	9	60	1.344	0.962

Note: This table presents the tail distribution characteristics for the categories Buildings and Others by canton.

TABLE C10 Effect of the characteristics of the tail of the distribution on the markup for the two categories: Buildings and Others.

	Dependent variable	
	Ln (Markup: Buildings)	Ln (Markup: Others)
Ln (1% Expected shortfall)	0.106 (0.158)	−0.478*** (0.206)
Constant	1.647*** (0.389)	3.420*** (0.654)
Observations	26	27
R^2	0.018	0.177
Adjusted R^2	−0.023	1.282
Residual Std. Error (df = 24)	1.410	1.282
F Statistic (df = 1; 24)	0.449	5.387**

Note: This table presents estimates of percentage changes in markup for the two categories, Buildings and Others, given the percentage change in expected shortfall at 1%. *, **, and *** refer to statistical significance at the 10%, 5%, and 1% levels, respectively.

TABLE C11 Effect of the characteristics of the tail of the distribution on the markup for the two categories: Buildings and Others.

	Dependent variable	
	Markup: Buildings	Markup: Others
Volatility	12.372 (30.988)	26.864 (17.885)
Constant	2.646 (45.424)	−14.769 (21.801)
Observations	26	27
R^2	0.007	0.083
Adjusted R^2	−0.035	0.046
Residual Std. Error (df = 24)	44.809	22.174
F Statistic (df = 1; 24)	0.159	2.256

Note: This table presents estimates of changes in markup for the two categories, Buildings and Others, given the change in volatility. *, **, and *** refer to statistical significance at the 10%, 5%, and 1% levels, respectively.

TABLE C12 Effect of the characteristics of the tail of the distribution on the markup for the two categories: Buildings and Others.

	Dependent variable	
	Ln (Markup: Buildings)	Ln (Markup: Others)
Ln (Volatility)	−0.828 (1.415)	0.455 (1.486)
Constant	2.115*** (0.560)	1.940*** (0.362)
Observations	26	27
R^2	0.014	0.004
Adjusted R^2	−0.027	−0.036
Residual Std. Error (df = 24)	1.413	1.411
F Statistic (df = 1; 24)	0.342	0.094

Note: This table presents estimates of percentage change in markup for the two categories, Buildings and Others, given the percentage change in volatility. *, **, and *** refer to statistical significance at the 10%, 5%, and 1% levels, respectively.

APPENDIX D: SHOULD RARE RISKS BE INSURED?

We apply the classic expected utility framework to analyze whether rare, but large, loss events, such as a pandemic, should be insured by a rational decision-maker. For simplicity, consider a decision maker (DM) with a utility function of wealth $U = \ln(W)$. The DM has the initial wealth of W_0 and faces the possibility of a loss L with probability p . The DM's expected utility, $E[U]$, is a probability-weighted average of the utilities in the states of loss and no loss:

$$E[U] = p \ln(W_0 - L) + (1 - p) \ln(W_0).$$

The DM is risk-averse, that is, when offered a choice between a lottery with the expected value V or a sure outcome of V , the DM strictly prefers the sure outcome.

The DM's risk aversion implies that the DM would buy full insurance if it were offered at the actuarially fair premium, $P_{\text{fair}} = pL$, in which case, DM's expected utility would be $\ln(W_0 - pL)$. However, because of risk aversion,

$$\ln(W_0 - pL) > E[U].$$

That is, the DM would be willing to pay an even higher premium than P_{fair} to fully insure the loss. The maximum premium that the DM is willing to pay to buy full insurance P_{max} is defined by equating DM's initial expected utility without insurance and its expected utility with full insurance at price P_{max} :

$$E[U] = U(W_0 - P_{\text{max}}).$$

The risk premium, P_p , is defined as the difference between the two prices:

$$P_{rp} = P_{\max} - P_{\text{fair}}.$$

It is positive for any risk-averse DM, and it measures the DM's willingness to pay for insurance.

The risk premium is useful for analyzing the DM's preferences to insure (i) low-frequency/high-severity risks, such as a pandemic, versus (ii) high-frequency/low-severity risks, such as a bike theft. To do so, we calculate the risk premium's value as a fraction of expected loss, $\frac{P_{rp}}{pL}$, (i) when the probability of loss goes to zero, $p \rightarrow 0$, versus (ii), when the loss goes to zero, $L \rightarrow 0$. Notably, given the logarithmic utility function, the value of P_{rp} is:

Rare, but large, loss risk premium

The proportional risk premium for insuring high-frequency/low-severity risk is equal to:

$$\lim_{p \rightarrow 0} \frac{P_{rp}}{pL} = \frac{W_0(\ln W_0 - \ln(W_0 - L)) - L}{L} > 0.$$

Therefore, for very rare risks with significant losses, the risk premium that a risk-averse DM is willing to pay is positive, both in absolute terms and as a percentage of the expected loss.

Frequent, but low, loss risk premium

The proportional risk premium for insuring a high-frequency/low-severity risk is equal to:

$$\lim_{L \rightarrow 0} \frac{P_{rp}}{pL} = 0.$$

Unlike the previous case, this one has very low severity risks, with the risk premium that a risk-averse agent is willing to pay goes to zero.

$$P_{rp} = W_0 - (W_0 - L)^p W_0^{(1-p)} - pL.$$

The distinction between the two cases is the behavior of the risk premium. In case of low probability, the risk premium converges to a positive value while in the case of low losses it converges to zero. Thus, the DM will be able to tolerate a higher price markup for the insurance against low probability/large loss events compared to the insurance against relatively more frequent but very low losses.