Have mitigating measures helped prevent insolvencies in Austria amid the COVID-19 pandemic?

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We employ a novel modeling approach to capture the impact of the COVID-19 pandemic on sectoral insolvency rates in Austria. Turnover shocks derived from a macroeconomic scenario generate stress to firms' profits and cash flows. Over time, both the equity and the liquidity (cash and bank) positions deteriorate, which causes insolvencies if firms fall under certain thresholds. Our model builds on data for nonfinancial incorporated Austrian enterprises available from the BACH and SABINA databases. Since only two firm-level variables (equity ratio, cash and bank) are available at sufficient coverage, we generate a hypothetical firm-level dataset for 17 NACE 1 sectors by using a Monte Carlo simulation.

The granularity of our model allows us to assess the impact of mitigating measures implemented in light of the COVID-19 shock. Such measures serve to cushion the loss of companies' revenue and households' income triggered by the COVID-19 containment measures. Put differently, they are meant to minimize the damage resulting from the deliberate temporary reduction in economic activity. In our analysis, we only investigate measures aimed at firms. These measures include equity injections via grants and subsidies (e.g. short-time work), long-term payment deferrals (e.g. credit guarantees) and short-term payment deferrals (e.g. social security contributions). We used all available data sources to calibrate the mitigating measures, with August 31, 2020, as cutoff date.

The model indicates a marked increase of COVID-19-induced insolvency rates, but mitigating measures reduce such insolvencies substantially. Without mitigating measures, the insolvency rate would rise to 5.8% by the end of 2020, more than quintupling its pre-crisis average (2017–2019: 1.0%). By end-2022, 9.9% of all Austrian firms would fail, which corresponds to an annual insolvency rate of 3.3%. With mitigating measures in place, the insolvency rate is significantly lower, reaching 2.1% by end-2020, and 6.9% by end-2022.

Projected insolvency rates should be interpreted with caution. The merit of this novel approach, however, lies less in the calculated sectoral insolvency rates themselves, but in the model's capacity to compare and rank the efficiency and efficacy of various mitigating measures. As to the current measures, we, for instance, find that credit guarantees appear most effective, followed by fixed cost support and short-time work. In the short term, delayed filing for insolvency is most efficient, but is set to mostly reverse itself in 2021, once public institutions recommence their usual practice.

At the OeNB, the model has also been used to assess implementation delays and the extension of mitigating measures. We intend to continuously extend the model, both in terms of its core functionality and the calibration of mitigating measures to address questions from (1) a macroeconomic perspective, in particular the loss of productive capacities (potential output), (2) a fiscal policy perspective, to estimate the costs of mitigating measures, and (3) a macro- and microprudential banking supervisory perspective, to provide a basis for estimating credit default probabilities for the banking system.

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The COVID-19 pandemic hit almost all countries worldwide in an unprecedented way. The supply side of economies was hit by measures implemented to contain the spread of the virus – lockdowns, business closures and social distancing – and by disruptions of global supply chains. At the same time, a drop in demand caused production to fall. Consumer demand was dampened by a combination of layoffs and heightened uncertainty about future income prospects. Investment decisions were hampered by extreme uncertainty about the path, duration and magnitude of the pandemic. These developments pose a serious threat to the survival of firms. Hence, the Austrian government has implemented a variety of measures meant to mitigate the negative economic impact on firms.

To assess the impact of these developments on sectoral insolvency rates, we developed a novel corporate insolvency model to forecast sectoral insolvency rates for Austrian firms and to assess the impact of the Austrian government's and other public institutions' mitigating measures.[2] The model is based on a simulated firm-level dataset that contains balance sheet, profit and loss as well as cash flow data. To our knowledge, we are among the first to develop such a model. There has, however, been some recent research that looks at how firms' liquidity position has evolved during the COVID-19 pandemic based on firm-level data.

The OECD (2020) evaluates the risk of a widespread liquidity crisis, using a cross-sector sample of almost 1 million European firms (Orbis database), and discusses the pros and cons of different kinds of public support measures. Without any policy intervention, 20% of the firms in the sample would run out of liquidity after one month, 30% after two months and 38% after three months. If the confinement measures lasted seven months, more than 50% of the firms would face a shortfall of cash, with this result mainly driven by the hardest-hit sectors. Among the broad range of measures introduced by OECD countries, direct and indirect wage subsidies seem to be the policy most critical to curbing the liquidity crisis, given the high share of wage costs in total spending. Adding up different policy measures (tax deferral, debt moratorium and wage subsidies at 80% of the wage bill), the simulation suggests that, after two months, government interventions would decrease the share of firms running out of liquidity from 30% to 10%, compared to the non-policy scenario.

De Vito and Gomez (2020) investigate to what extent COVID-19 might affect the liquidity of listed firms across 26 countries. They use consolidated firm-level data for the fiscal year 2018, obtained from the Compustat Global and North America databases. They stress-test three liquidity ratios for each firm with full and partial operating flexibility in two simulated distress scenarios. In addition, they study the impact of two different fiscal policies, namely tax deferrals and bridge loans. In the most adverse scenario, an average firm with partial operating flexibility would exhaust its cash holdings within about two years. About 10% of all sample firms would become illiquid within six months.

Guerini et al. (2020) simulate the COVID-19 impact on corporate solvency from a sample of 1 million French companies (FARE data 2017). They find that the share of firms with negative equity increases by 1.4 percentage points (from 1.8% in a world without crisis to 3.2%), which corresponds to an increase of almost

[2] *In addition to the government, Austria's health insurance providers (deferral of social security contributions) and the banking sector (debt moratoria) also introduced mitigating measures.*

80%. At the same time, they observe an increase of firms with liquidity problems from 3.8% to more than 10%.

Gourinchas et al. (2020) estimate the COVID-19 impact on business failures among small and medium-sized enterprises in 17 countries, using a large representative firm-level database (Orbis). They use a simple model of firm cost minimization and measure each firm's liquidity shortfall during and after COVID-19, arriving at a quasi-doubling of business failures: the non-COVID-19 bankruptcy rate of 9.4% rises to 18.2% amid the coronavirus pandemic, which reflects an 8.8-percentage-point increase. Schivardi and Romano (2020) propose a simple method based on firms' balance sheet data from the Orbis database and sectoral predictions of sales growth to determine the number of illiquid firms for Italy on a monthly basis. They find that, at the peak of the pandemic, almost one-third of the firms become illiquid. Carletti et al. (2020) use the Orbis dataset of 80,000 Italian firms to study the impact of the pandemic on firms' net worth. They find that 17% of the firms would have negative net worth by the end of 2020. What is unique in our approach compared to the cited studies above is our parsimonious approach to firm-level data, while we still model measures at a very granular level.

The paper is structured as follows. In section 1, we present a macroeconomic projection scenario at the sectoral level that is the main driver of stress for firms. In section 2, we present the mitigating measures implemented by the Austrian government and other public institutions. Section 3 explains the corporate insolvency model. In section 4, we discuss how we implemented the mitigating measures in the insolvency model. In section 5, we present the Monte Carlo approach that we use to simulate our firm-level data. Section 6 presents the results, and section 7 concludes.

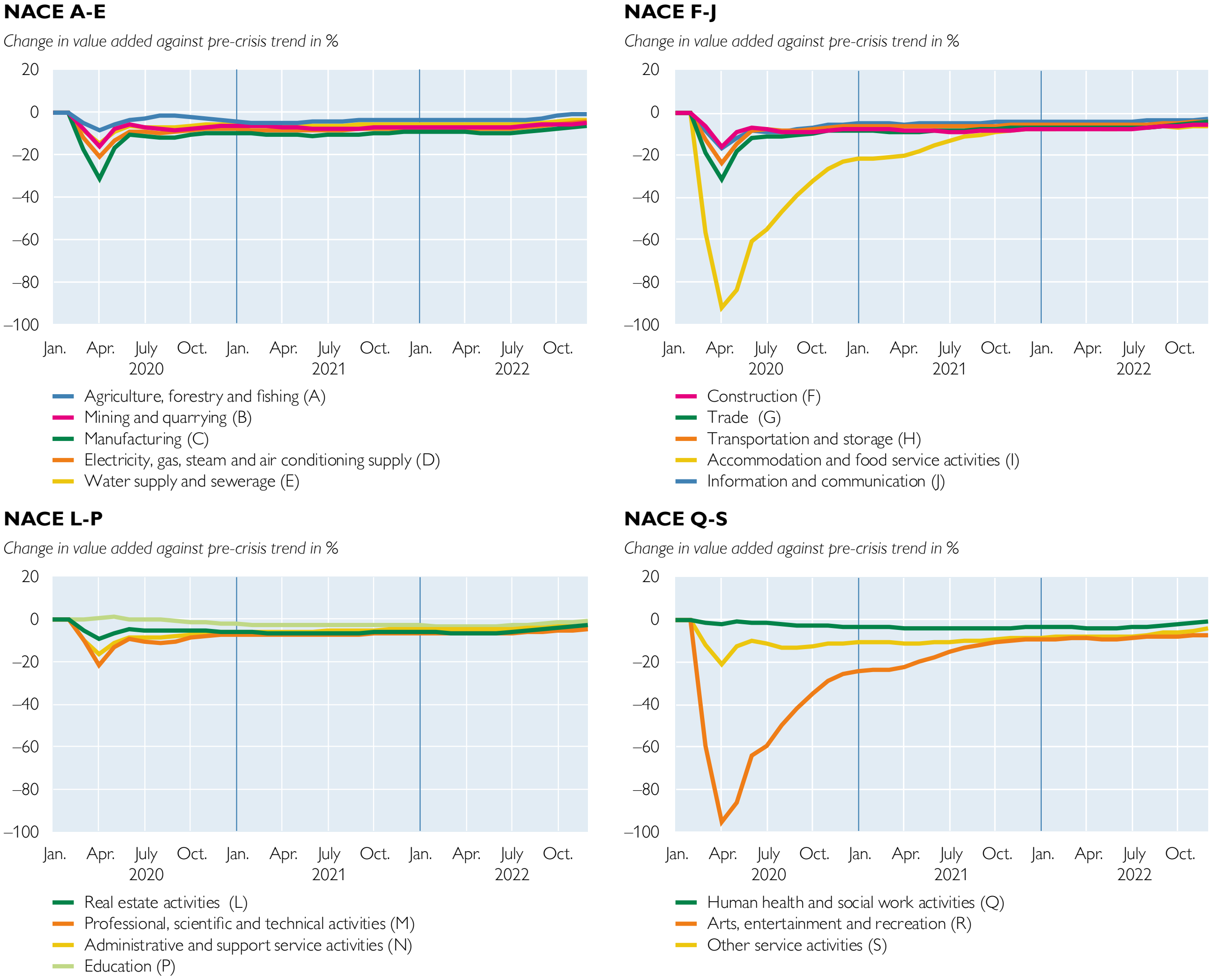
1 A macroeconomic projection scenario at the sectoral level

The macroeconomic scenario is the main driver of stress to firms. The impact of the COVID-19 pandemic on the economy is huge and unprecedented in combining negative supply and demand shocks. Our projection scenario is based on the June 2020 forecast of the OeNB. In this forecast, the OeNB expects real GDP to decline by 7.2% in 2020, followed by increases of 4.9% and 2.7% in 2021 and 2022. This forecast was produced based on quarterly national accounts data. Instead of projecting highly aggregated quarterly national accounts variables, we base the scenario spanning the period up to end-2022 on a monthly forecast of 13 demand components: 7 private consumption components (food and beverages; housing (including energy and water); clothing, footwear and furnishings; recreation, sports and culture; restaurants and accommodation services; transport; other consumption), 2 investment categories (construction, other investment), 2 export categories (tourism, other), government consumption and changes in inventories. We map the 13 demand components to the 74 goods categories of an input-output model that we developed for this purpose. We use this model to calculate the effects this demand shock has on the output of all 74 industries due to intermediate goods linkages.

The results of our projection scenario for the NACE-1-digit sectors can be found in chart 1 and table A1. Two sectors clearly stand out. Arts, entertainment and recreation (NACE R) and accommodation and food service activities (NACE I) are expected to suffer output losses of 46% and 43%, respectively, relative to the

Chart 1

COVID-19 impact on the Austrian economy



Source: OeNB.

pre-crisis trend in 2020. Manufacturing (–12%), trade (–12%), other service activities (–11%), professional, scientific and technical activities (–9%), electricity, gas, steam and air conditioning supply (–9%) and administrative and support service activities (–8%) will also be hit to a considerable extent. The reported output loss figures relate to the mean loss over all firms of each sector.

In addition, even within the same sector, the shock will impact firms differently. To account for this, we assumed that, for individual firms within each sector, the shock is distributed according to a normal distribution. This assumption allows us to model various effects more realistically, and it is an outright necessity to address fixed cost grants properly. The mean of the distribution equals the shock size per sector for each period. We calibrated the variances based on the heterogeneity of the sector and the shock magnitude.[3]

2 Mitigating measures

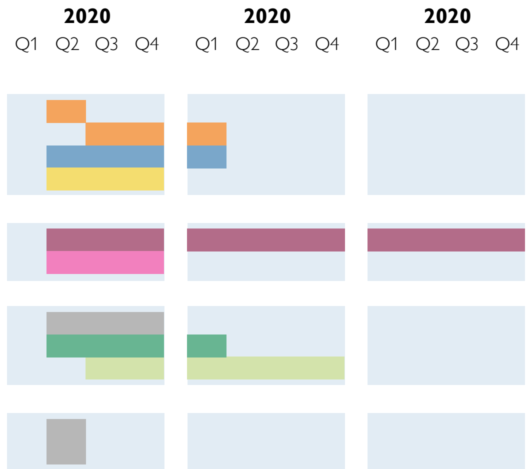
Mitigating measures serve to cushion the loss of firms' revenue and households' income triggered by the COVID-19 containment measures in order to minimize the damage from the deliberate temporary reduction in economic activity. In our analysis, we investigate measures aimed at firms.[4] These include fiscal measures by the Austrian government and other legislative measures as well as private initiatives, such as private bank moratoria. For the purpose of this paper, we classify them, within our model, by their mechanics. We distinguish between equity injections via grants and subsidies (e.g. short-time work), long-term payment deferrals (e.g. credit guarantees) and short-term payment deferrals (e.g. social security contributions). We used all available data sources to calibrate the mitigating measures (see figure 1). Where we had no data on the actual use, we assumed that all eligible firms apply to maximize payouts. Note that August 31,2020, is the cutoff date for all mitigating measures and associated reporting included in this analysis.

We are now going to briefly describe each of the four categories of mitigating measures.

Figure 1

Overview of mitigating measures

	Characteristics		
	Available *EUR billion*	By whom	In model *EUR billion*
Capital injections via grants and subsidies			
Fixed cost support (FKZ)	8	Government	3.4
Fixed cost support 2 (FKZ II)	12[1]	Government	7.8
Short-time work	11	Government	11
Sector-specific measures	0.6 + 0.5	Government	0.6 + 0.5
Long-term deferrals of payment obligations			
Credit guarantees	16	Government/	7.6
Debt moratoria	n. a.	Banks	1.9[2]
Short-term deferrals of payment obligations			
Reduction of corporate tax advance payments	n. a.	Government	0
Deferral of social security contributions	n. a.	Social security	3.0 (peak)
Delayed insolvency filing due to deferral	-	Social security	-
Changes to the insolvency regime			
Temporary change to the insolvency law	-	Government	-
Suspended bankruptcy filings (public sector)	-	Social security	-



Source: Authors' compilation.

[1] *Including fixed-cost support (FKZ).*
[2] *Actual long-term liquidity support.*

[3] *An additional criterion was that the share of firms with output losses during the shutdown phase above 100% (for which we set the loss to 100%) is lower than 1%.*

[4] *There are several other mitigating measures in place, most importantly the hardship fund, which, however, do not specifically address firms. For this reason, we excluded them from our analysis.*

2.1 Capital Injections via grants and subsidies

Financing of fixed costs for particularly hard-hit industries[5]

With the initial funding guidelines for grants for fixed costs (Fixkostenzuschuss-Richtlinie – FKZ) and their extension (FKZ II), the Austrian government introduced grants to cover firms' operating costs. Such grants are awarded to companies that have suffered a loss in sales of at least 40% (FKZ) or 30% (FKZ II). The fixed cost subsidy is staggered and capped depending on the turnover loss. In addition, several eligibility criteria are meant to ensure that firms that came into trouble because of the COVID-19 containment measures may apply, but not firms that were already struggling before. The overall volume of this measure amounts to EUR 12 billion.

COVID-19 short-time work[6]

The COVID-19 short-time work allowance is a modification of an instrument that was already used during the financial crisis. It was initially designed for a duration of three months (phase 1: until the end of June 2020), with an option to extend it by another three months (phase 2: until the end of September 2020). In July, the Austrian government extended the short-time work scheme by six months until the end of March 2021 (phase 3). Under this scheme, employees receive income support amounting to between 80% and 90% of their previous net wage or salary. The amount depends on their original net wage or salary and is capped at the maximum contribution basis for social security. During the first two phases, it was possible for firms to reduce employees' working hours – and thus remuneration – by 10% to 90%. In phase 3, working time may be reduced by 20% to 70%.

Sector-specific measures[7]

The support package for hospitality venues such as restaurants ("Wirtshauspaket"), which amounts to EUR 500 million, combines tax relief with measures aimed at stimulating demand. The emergency aid for the tourism sector includes bridge financing of up to EUR 100 million for domestic tourism. The overall volume of support measures comes to EUR 600 million.

[5] *Fixed cost support is based on Article 3b paragraph 3 of the Act establishing a government-owned holding company for wind-down purposes (Bundesgesetz über die Einrichtung einer Abbaubeteiligungsaktiengesellschaft des Bundes – ABBAG; Federal Law Gazette I No. 12/2020), and two guidelines, namely guidelines for grants for fixed costs (phase 1) (Fixkostenzuschuss-Richtlinie, Federal Law Gazette II No. 225/2020) and guidelines for grants for fixed costs (phase 2)(Fixkostenzuschuss-Richtlinie 800.000, Federal Law Gazette II No. 326/2020).*

[6] *Short-time work is based on Article 37b Public Employment Service Act (Arbeitsmarktservicegesetzt – AMSG; Federal Law Gazette I No. 71/2020).*

[7] *The measures supporting restaurants are mainly based on a temporary tax relief granted pursuant to Article 28 paragraph 52 VAT Act 1994 (Federal Law Gazette I No. 60/2020).*

2.2 Long-term payment deferral

Credit guarantees[8]

The Austrian government introduced several measures to provide support by guaranteeing new loans. Note that the new framework was put on top of existing structures and their guarantee products. As at end-August 2020, eight different guarantee schemes had been designed, each with its own terms and eligibility criteria. The overall volume of earmarked guarantees amounts to EUR 15 billion. By end-August 2020, Austrian companies had drawn roughly EUR 6 billion of this amount according to data reported to the OeNB (EBA, 2020b).

Debt moratoria[9]

While the Austrian government also introduced a legislative moratorium on bank debt, eligibility restrictions mostly exclude incorporated firms. However, a private, i.e. nonlegislative, sector-wide debt moratorium (EBA, 2020a) peaked at EUR 14 billion (of affected credit volume) in June 2020, according to data reported to the OeNB (EBA, 2020b).

2.3 Short-term payment deferral

The Austrian government agreed on a tax relief package that contains various measures, including a reduction of 2020 corporate tax advance payments to zero, and a deferral of social security contributions. Since we focus on firms that suffer losses and hence face bankruptcy risk, we do not consider the former measure in our model. The deferral of social security contributions, by contrast, has an impact on all firms. Firms directly affected by the lockdown measures were automatically selected for the (interest-free) deferral for the period from February to April 2020. Other firms with COVID-19-related liquidity problems can apply for this measure. From August to December 2020, all firms can apply for an additional three-month deferral. Firms must pay the contributions until mid-January 2021. In case of persistent payment difficulties, they can also apply for payment in eleven installments, beginning in February 2021. Interest must be paid for all post-April 2020 contribution periods.

2.4 Changes to the insolvency regime

The Austrian government also introduced a temporary change to the Austrian insolvency law.[10] From April to October 2020, overindebtedness was suspended as a basis to open insolvency procedures. In addition, tax authorities and public health insurance providers agreed to suspend bankruptcy filings from March to May 2020.

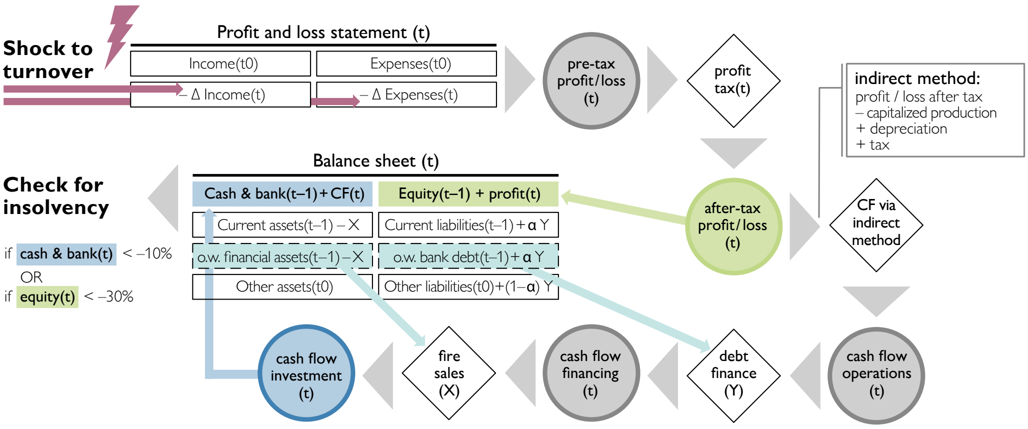
[8] *Credit guarantees are based on three different laws and extended by COFAG, the Austrian COVID-19 financing agency, pursuant to Article 6a paragraph 2 of the Act establishing a government-owned holding company for wind-down purposes (Bundesgesetz über die Einrichtung einer Abbaubeteiligungsaktiengesellschaft des Bundes – ABBAG; Federal Law Gazette I No. 12/2020); austria wirtschaftsservice (aws), a state-owned bank providing funding for Austrian companies, pursuant to Article 1 paragraph 2a Guarantee Act 1977 (Federal Law Gazette I No. 23/2020); the Austrian Hotel and Tourism Bank ÖHT and aws, pursuant to Article 7 paragraph 2a SME Promotion Act (Federal Law Gazette I No. 16/2020).*

[9] *The public debt moratorium is based on Article 2 2nd COVID-19 Act (Federal Law Gazette I No. 58/2020), the private sector-wide debt moratorium is based on EBA (2020a).*

[10] *The insolvency moratorium is based on Article 9 2nd COVID-19 Act (Federal Law Gazette I No. 58/2020).*

Figure 2

Stylized overview of the insolvency model without mitigating measures



Source: Authors' compilation.

Note: CF stands for cash flow, and o.w. for of which.

3 The corporate insolvency model

Figure 2 shows a stylized version of the corporate insolvency model. For each firm, the model considers that firm's profit and loss statement, its cash flow statement and its balance sheet. We simulate 100,000 firms per sector and calculate the effects of sector- and firm-specific shocks to profitability and, subsequently, liquidity, with liquidity being a function of a firm's profitability and balance sheet characteristics. We evaluate on a monthly basis whether firms fall below specific thresholds for solvency or liquidity, which triggers insolvency. This section explains the model in more detail. The model equations can be found in annex 2.

3.1 Profit and loss statement

A turnover shock in period *t* derived from a macroeconomic scenario generates stress to firms' income that can only be partly offset by a reduction in expenses. We stress financial income in line with the sectoral turnover shock and account for production-related costs and various fixed costs, including interest payments and depreciation. A crucial part here is the calibration of firms' responses to a fall in turnover.

In our simulation experiment, firms react by reducing their nominal cost components. We do not distinguish between the reduction of the quantity of the cost components and their prices. We do this by calibrating response elasticities of the different cost components with respect to changes in turnover (see table A2 in annex 1). Such an elasticity describes the percentage decline of a cost component relative to the percentage decline of turnover. We distinguish between cost components that are (partly or completely) related to the volume of production and cost components that are fixed in the short run. The costs of intermediate goods are directly related to the volume of production, which suggests an elasticity of 1. Due to firms' contractual obligations, we assume a slightly lower elasticity of 0.9 for all industries. Expenses for external supplies and services (e.g. maintenance of plants and buildings or the consumption of energy and water) are only partly related to the volume of production. Hence, we assume an elasticity of 0.5 for all industries. For staff costs, we use data on unemployment and on the take-up of short-time work. We calculated sector-specific elasticities by dividing the cost savings (in % of the total wage bill), derived from laying off workers and receiving payments for short-time work at the beginning of May 2020, by the decline of turnover in April 2020. In the scenario without short-time work, we assumed that firms lay off 50% of the workers for whom they, in fact, used short-time work.

Income and expense positions at time t are calculated as changes versus the starting value *t0*. This yields a new pre-tax profit, which is booked against equity (from *t–1*). In case of a positive pre-tax profit, we tax it with the implicit corporate tax rate of 15%.[11]

3.2 Cash flow statement

We derive the operating cash flow of each firm in period *t* based on the indirect method, which uses the pre-tax profit as a starting point, and adjust it for all noncash transactions. In our case, we account for capitalized production and depreciation/amortization but exclude any other structural changes of the balance sheet, such as a decrease (increase) in accounts receivable or a decrease (increase) in inventories. These simple accounting identities yield the net cash flow from operating activities.

For the cash flow impact of financing activities, we solely focus on refinancing bank debt. As we take the starting balance sheet structure as a given, we do not account for the possibility of firms' access to new credit in the standard model. For refinancing, we introduce active banks. Any given firm with an equity ratio above zero is assumed to refinance its current bank debt, i.e. maturing bank debt and installments. To reflect the repayment of loans, firms do not refinance 100% but only 80%. We use this rate to match the historical ratio of interest to principal payments (see Schneider and Waschiczek, 2018).

Firms with an equity ratio of zero or less, however, will not be able to refinance their current bank debt. Yet, they will be able to use undrawn credit lines, which are significant according to data reported by banks to the OeNB. Hence, in our model the impact on firms' cash flow is 80% of the simulated current bank debt position.[12]

Finally, we assume that firms' debt profile is stable over time, i.e. repayment is spread evenly across months for the first year, and current bank debt in the second and third year resembles current bank debt at *t0*. No other firm behavior is considered for calculating the cash flow after financing.

For the cash flow impact of investment activities, we take an even more restrictive approach. In line with the static balance sheet assumption, we assume that firms do not invest. There is one important exception: firms with a negative cash flow (first occurrence) can divest. The result is an unrealistic evolution of surviving

[11] *While 15% does not match Austria's statutory corporate tax rate of 25%, aggregate simulation results without a turnover shock based on the lower figure match the historical tax rates (measured as a share of the total balance sheet) of the BACH time series.*

[12] *Undrawn credit lines are part of banks' supervisory reporting to the OeNB (previously for the central credit register, now granular credit data reporting or GCR). It is, however, not possible to directly match the BACH/SABINA databases with banks' reporting. Hence, the calibration of 20% – while broadly matching aggregates – has to be considered experimental or preliminary.*

firms' balance sheets, but as we are mostly interested in the insolvency rates at this stage, investments would hardly play a role. As far as divestments go, firms can only sell current other financial assets (restrictive), but they can sell at book value at short notice, i.e. without an additional equity impact due to a fire sale haircut.[13] Additional cash flows from divestment leave us with the cash flow after investments, which is used to update the cash and bank position in each firm's balance sheet.

3.3 Balance sheet

Broadly speaking, we model three categories of assets and liabilities: first, the buffers against insolvency, i.e. an aggregate liquidity position (cash and bank) on the asset side and an equity position on the liability side (equity). Second, we include current assets and liabilities, broken down into three subcategories to model firms' cash flows. However, at this juncture, only current other financial assets (available for divestment) and current bank debt (that needs to be refinanced) are considered in our model. Third, we combine all other assets and liabilities, respectively, as they do not yet play a role in our model.

3.4 Insolvency thresholds

Both in general and according to Austrian insolvency law, corporate insolvencies can be triggered either by overindebtedness or illiquidity. To reflect these two dimensions in our model, we consider the equity and the aggregate cash and bank positions relative to total assets as best measure, respectively. We introduce two separate thresholds, namely –30% for the equity ratio and –10% for the liquidity ratio, i.e. cash and bank, to flag insolvency. A firm becomes insolvent if it falls below one of these thresholds, and the firm remains insolvent even if future profitability leads to a return above the threshold. While the threshold for overindebtedness is well justified by empirical evidence[14], the foundation for the illiquidity threshold is weaker. We use a negative liquidity threshold (instead of zero) since the firms can rely on undrawn credit lines from banks.

4 Implementation of the measures in the insolvency model

Figure 3, which adds mitigating measures to figure 2, shows how the above-mentioned measures are implemented in the model. Note that the current calibration assumes maximum efficiency for all stakeholders: firms know when they are eligible for a measure and apply right away and the institutions charged with executing the measures pay out immediately.[15] This section explains the calibration in more detail.

4.1 Capital injections via grants and subsidies

The *fixed cost grant* can be implemented easily, as both the eligibility criteria and the subsequent payouts are codified in law: the criteria as thresholds for lost turn-

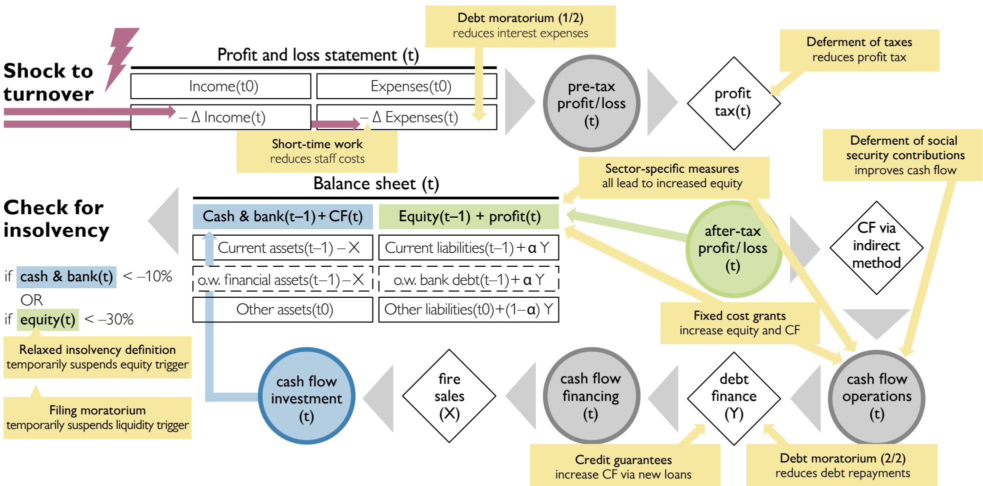
[13] *Of all the assumptions in our model, these probably have the weakest economic foundation and need to be considered purely ad-hoc-ish.*

[14] *We set the overindebtedness threshold at –30% for two reasons: (1) based on this threshold, we replicated recent insolvency rates per sector at the starting point, and (2) cross-country empirical studies show that the equity ratio commonly associated with insolvency ranges from –30% to –35% (see Davydenko, 2007).*

[15] *One of the next model development steps is to relax this assumption and to replace it by more realistic assumptions based on experience gained with the measures.*

Figure 3

Stylized overview of the insolvency model with mitigating measures



Source: Authors' compilation.

Note: CF stands for cash flow, and o.w. for of which.

over for a period of up to three months, namely from mid-March to end-July 2020 (phase 1 or FKZ), or up to four months, namely from June 2020 to mid-March 2021 (phase 2 or FKZ II), and the payouts as a share of fixed costs. Grants are not mutually exclusive, i.e. firms can apply for FKZ and FKZ II. They must, however, provide proof that they did not request support for the same expenses twice. In the insolvency model, we include these payout shares for the BACH positions operating charges and interest expenses. As some optionality is included, firms that apply for fixed cost support maximize payout. Nevertheless, of the overall FKZ volume, less than EUR 4 billion, or half of the endowment, is paid out in our simulation. This changes with FKZ II, when more than EUR 11 billion (of 12) are paid out. The payouts are modeled as even shares from the month after the first possible application to one month after the application deadline.

The impact of *short-time work* on staff costs is based on data on the take-up of short-time work as explained above. Short-time work reduces staff costs and hence directly impacts on profits. Payout is assumed to be immediate.

Given the multitude of transmission channels of the measures sketched out above and the lack of eligibility criteria, we treat *sector-specific measures* as an equity injection to all firms of a given sector and calibrate the volume as a share of turnover. A 2.5% share of turnover leads to a payout of EUR 600 million across all firms of the sector. Payout is again immediate.

4.2 Long-term payment deferral

At end-August 2020, eight different *credit guarantee schemes* were in place. In our model, we cannot replicate them given the current granularity of simulated data. Hence, our modeling strategy relies on broader, common characteristics of the guarantees that are applied evenly across all firms. A firm will apply for a guaranteed loan the first time it faces a negative cash flow in an observation period. In line with most guarantee schemes, the credit-issuing bank will vet the applicant firm and only grant credit in case of a positive equity ratio (the same criterion is applied for rolling over credit). However, these restrictions are still too soft and would result in the issuance of guaranteed credit of more than EUR 32 billion. This figure is more than twice the overall volume available or four times the guarantees that have been granted to incorporated firms by end-August 2020. Consequently, we introduce a random approval rate of between 40% and 70% to match data that are available on a monthly basis. Payout is immediate.

Debt moratoria somewhat resemble credit guarantee schemes. Again, we have to make some broad-based assumptions in light of the different types of moratoria and, even more so, the lack of details regarding private moratoria. However, the OeNB disposes of reporting data – from April 2020 onward – that shed light on the use of debt moratoria. To match these data, we apply the following rules: any firm that makes a loss in April 2020 (worst monthly turnover shock for all sectors) applies for this measure. 15% of applicants are granted relief from interest and principal payments from April to June 2020. From July to December 2020, the moratoria are phased out in equal steps, which we calibrated based on data reported for July and August 2020. Payout is again immediate.

4.3 Short-term payment deferral

The deferral of corporate tax payments has no effect on insolvency rates in our model, since only firms with a negative profit can become insolvent. While impacting on the cash flow, the deferral of social security contributions has no impact on profits, since incorporated firms must use the accrual principle when preparing their balance sheet. The filing moratorium was implemented such that 50% of illiquidity-induced insolvencies are not triggered for the year 2020. This reduced share equals the share of filed bankruptcies seen by tax authorities and public health insurance providers in normal times. Moreover, it is assumed that these institutions postpone their filings further as firms are offered the option to apply for payment in installments until end-2021. For this reason, we phase out the 50% in equal steps from February 2021 onward. This is meant to reflect a lack of filing opportunities due to the deferral of payments and administrative red tape. In other words, not all insolvencies can be immediately filed in February 2021, when the first deferred social security payments will become due.

4.4 Changes to the insolvency regime

We model the temporarily relaxed insolvency law by excluding the overindebtedness trigger from April to June 2020.

5 A Monte Carlo exercise to simulate firm-level data

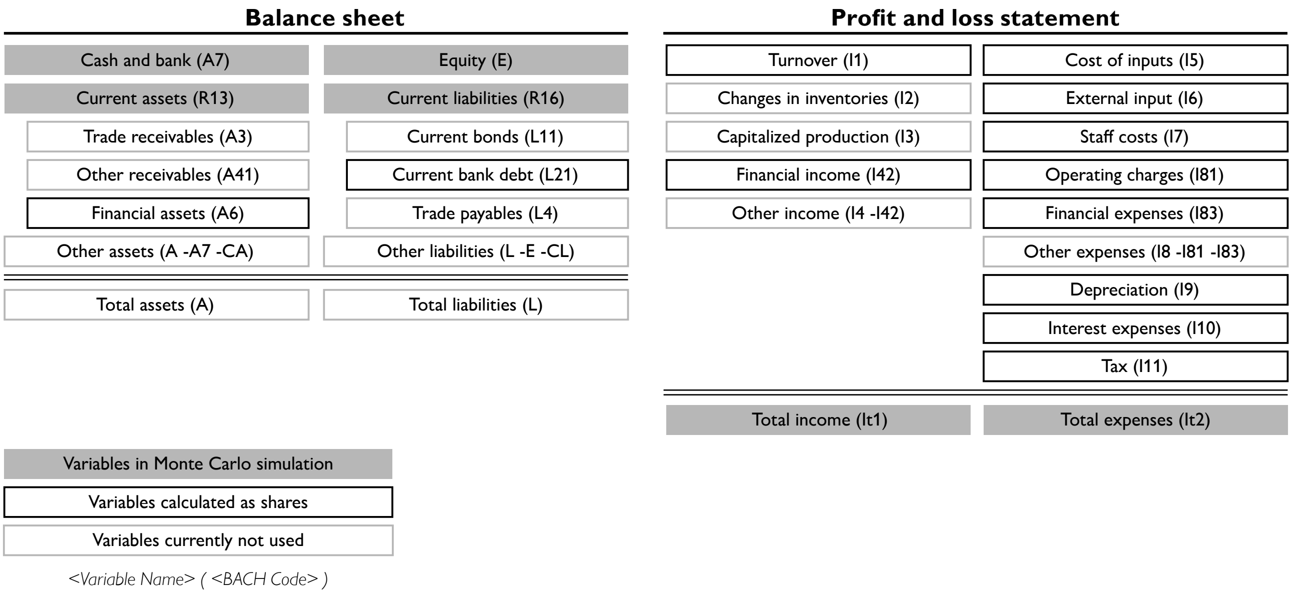
The model builds on a firm-level dataset for nonfinancial incorporated Austrian enterprises with 18 firm-specific variables[16] for 17 NACE-1 sectors.[17] We use data

[16] *See table A3 in annex 1 for a detailed description of the variables.*

[17] *Although the firm-level data set has been constructed for incorporated firms, the projected sectoral insolvency rates hold for all firms of a sector. The reason is that we have calibrated the model to fit sectoral historical insolvency rates. The firm-level data set gives information on the structure of the balance sheet and the profit and loss account only, but not on the size of the firms. We make the simplifying assumption that all firms within a sector have the same size.*

Figure 4

Variables of the firm-level dataset



Source: Authors' compilation.

from the BACH[18] and SABINA[19] databases to construct this dataset. Since only two variables at the firm level (equity ratio, cash and bank) are available to a sufficient extent in the SABINA database, we generate a hypothetical firm-level dataset. To this effect, we proceed in two steps. First, we simulate a firm-level dataset for six core variables (equity ratio, cash and bank, current assets, current liabilities, total income, total expenses) by means of a Monte Carlo method[20]. These core variables are shaded in gray in figure 4. Second, we calculate all other variables used (black font) as shares of the simulated variables on a sectoral basis.

What we need to perform the Monte Carlo simulation is the distribution of each variable over all firms in that sector and a covariance matrix that describes the joint distribution of all variables. We use a copula[21] approach, since it provides a flexible way to separately model the dependence structure between the variables and the marginal distributions (McNeil et al., 2015).

The first step of the Monte Carlo simulation is to estimate marginal distributions for all variables. For the equity ratio and cash and bank, we draw on firm-level data that are available in the SABINA database for more than 110,000 firms.

[18] *BACH is a database of aggregated and harmonized accounting data of nonfinancial incorporated enterprises of 13 European countries. It contains over 100 variables for 17 NACE sections, about 80 NACE divisions and 4 firm size classes (https://www.bach.banque-france.fr/?lang=en). Besides the weighted mean, data for the quartiles of the distribution for each variable are available.*

[19] *The SABINA database contains firm-level accounting data compiled by Bureau van Dijk for more than 130,000 Austrian firms.*

[20] *Monte Carlo simulation is a mathematical technique that generates random variables for modeling risk or uncertainty of a certain system. The random variables or inputs are modeled based on probability distributions such as normal or gamma distributions.*

[21] *A copula is a multivariate cumulative density distribution for which the marginal distribution for each variable is uniform.*

Table A4 in annex 1 shows some statistics of the equity and cash and bank ratios from the SABINA database. The other four core variables (current assets, current liabilities, total income, total expenses) are taken from the BACH database, which contains aggregated data for the weighted mean and for the quartiles. We use the weighted mean and the first quartile to estimate the distributions for these variables. We assume a normal distribution for total income and total expenses and a gamma distribution for current assets and current liabilities.

Using a copula makes the simulation an easy task. For each sector, we generate 100,000 draws from a multivariate normal distribution $X = N(0,1,\sigma)$. Therefore, we need a correlation matrix that describes the dependencies between the variables. Since we have no micro data to estimate this matrix, we use correlations over time between the means of pairs of variables as a proxy. We then compute the cumulative density function (cdf) of this multivariate normal distribution, which is uniformly distributed in the interval [0,…,1]. The final step involves specifying the inverse cumulative density function for each variable. We can use any distribution family if we are able to compute the inverse cdf. For the equity ratio and cash and bank, we use the inverse cdf of the data[22]. For the other variables, we either use the inverse normal or the inverse gamma cdf.

Our simulated dataset has all the properties that we need to perform our analysis (marginal distributions that are identical to the estimated distributions and a correlation structure that is given by the estimated correlation matrix[23]). The blue lines in chart 2 show the simulated marginal distributions for our six core variables for manufacturing (NACE C). For the equity ratio and the cash and bank ratio, we also plotted the empirical distributions (red line). Four points are worth mentioning. First, our simulation approach effectively reproduces the empirical marginal distributions. Second, the distribution for the equity ratio is far from normal, which highlights the importance of the availability of firm-level data for this variable[24]. Third, a considerable share of firms has negative equity in 2018 (14% for manufacturing, 17% across all sectors). Fourth, we removed firms with equity of less than –30% from our dataset since such firms are insolvent according to our definition. It is evident from the panels in chart 2 that some firms have an equity ratio of below –30% (and some of above 100%). This is because the panels are based on a kernel density estimator, which smoothens the distributions.

6 Results

The model indicates a marked increase of insolvency rates, with mitigating measures reducing COVID-19-induced insolvencies more strongly in the short than in the medium term. Without mitigating measures, the insolvency rate would rise to 5.8% at the end of 2020, reaching more than five times its pre-pandemic

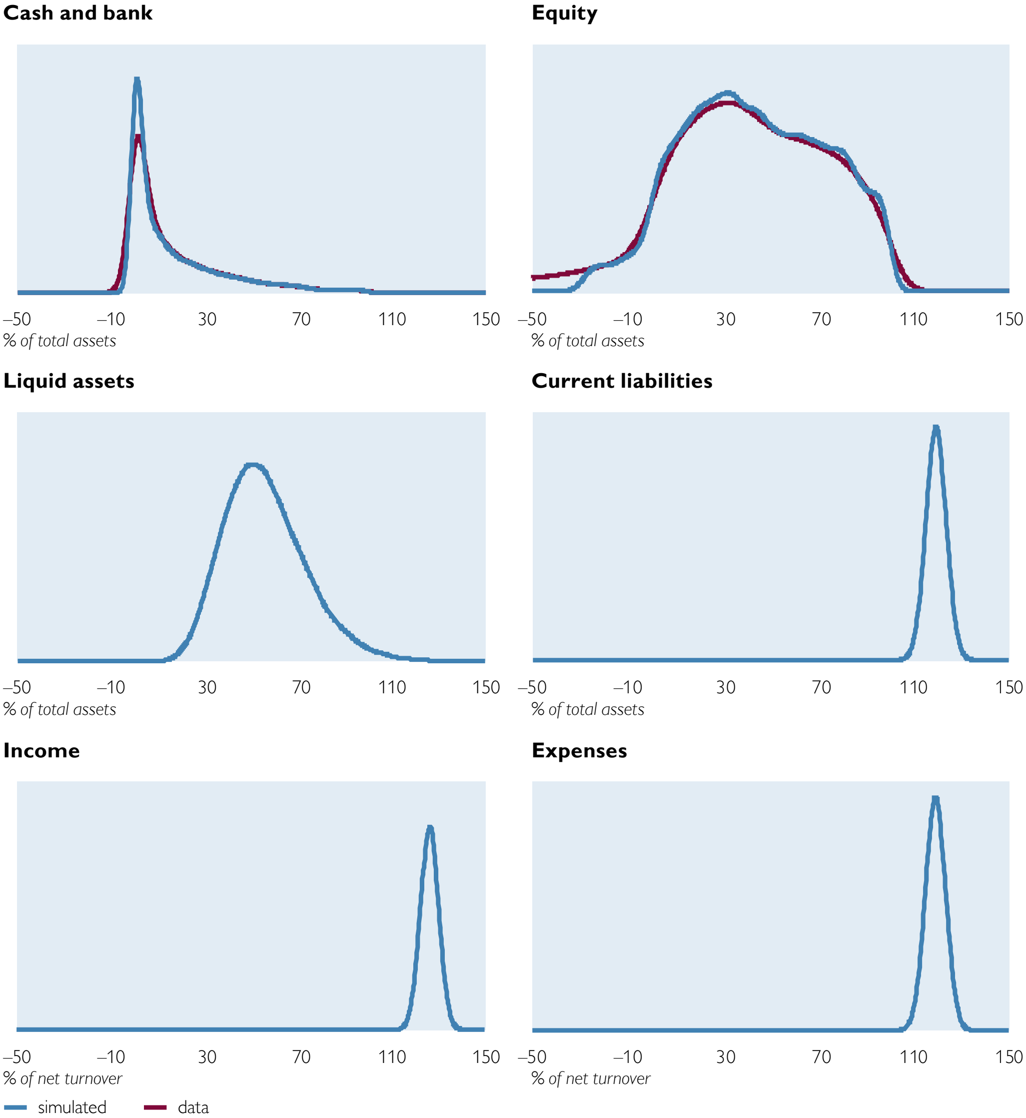
[22] *In this case, the inverse cdf simply involves referring to the i*Nth element of the sorted data, where i is the uniformly distributed value of the simulated copula for that variable and N the number of firms.*

[23] *Note that the copula approach does not allow to exactly reproduce the correlation structure for all families of marginal distributions other than normal distributions. What can be reproduced exactly is the rank correlation matrix. However, the error is marginal for our data.*

[24] *It would be possible to construct the firm-level dataset with variables from the BACH database only. However, according to SABINA firm-level data, the distribution of the equity ratio deviates considerably from a normal distribution for most sectors. For the cash and bank ratio, the distributions are very similar to a gamma distribution for all sectors.*

Chart 2

Marginal distributions of the simulated dataset for manufactoring (NACE C)



Source: Authors' calculations.

average (2017–2019: 1.0%). By end-2022, 9.9% of all Austrian firms would fail, which corresponds to an annual insolvency rate of 3.3%. With mitigating measures in place, the insolvency rate is significantly lower, reaching 2.1% by end-2020[25]

[25] *By the time of publication, the historically low realised insolvency rates according to KSV data end up well below our model results. The explanation is two-fold: (i) the underlying macroeconomic scenario underestimated the economic rebound in Q3 2020, particularly for the hardest hit sectors (most importantly NACE I but also R, i.e., accommodation and food service activities and arts, entertainment and recreation). Including a scenario with the Q3 rebound in the model would drive down insolvency rates significantly, however, not to the empirically observed levels. (ii) is based on economic intuition and anecdotical evidence: in light of an expanding set of mitigating measures – and the corresponding hope to turn things around – firms do not have any incentives to open insolvency proceedings right now (which is corroborated by anecdotical evidence). As for our models predicted insolvency rates, given what we know now – at the time of publication – they are indeed too high for 2020, but should not fall to empirically observed levels, because firms' strategic behaviour indicates a back log of future insolvencies.*

Chart 3

Impact of COVID-19 and of all mitigating measures on Austrian firms' insolvency rates

Source: Authors' calculations.

and 6.9% by end-2022. Such measures therefore help reduce additional, COVID-19-induced insolvencies by two-thirds in 2020 and by one-third by end-2022. For the aggregate economy, chart 3 shows monthly insolvency rates without (solid blue line) and with mitigating measures (solid red line), as well as the difference (dotted yellow line) for both monthly insolvency rates (left panel) and the cumulative insolvency rate (right panel).

As is evident from chart 3, at the height of the COVID-19-induced lockdown in the second quarter of 2020, even mitigating measures could only reduce the impact on insolvency rates so far. Yet, the substantial support offered to firms in the second half of 2020 brings rates down substantially. However, in case of short-term liquidity measures and the filing moratorium, this partially comes at the expense of higher insolvency rates in 2021 – note that the solid red line moves above the blue line in the left panel.

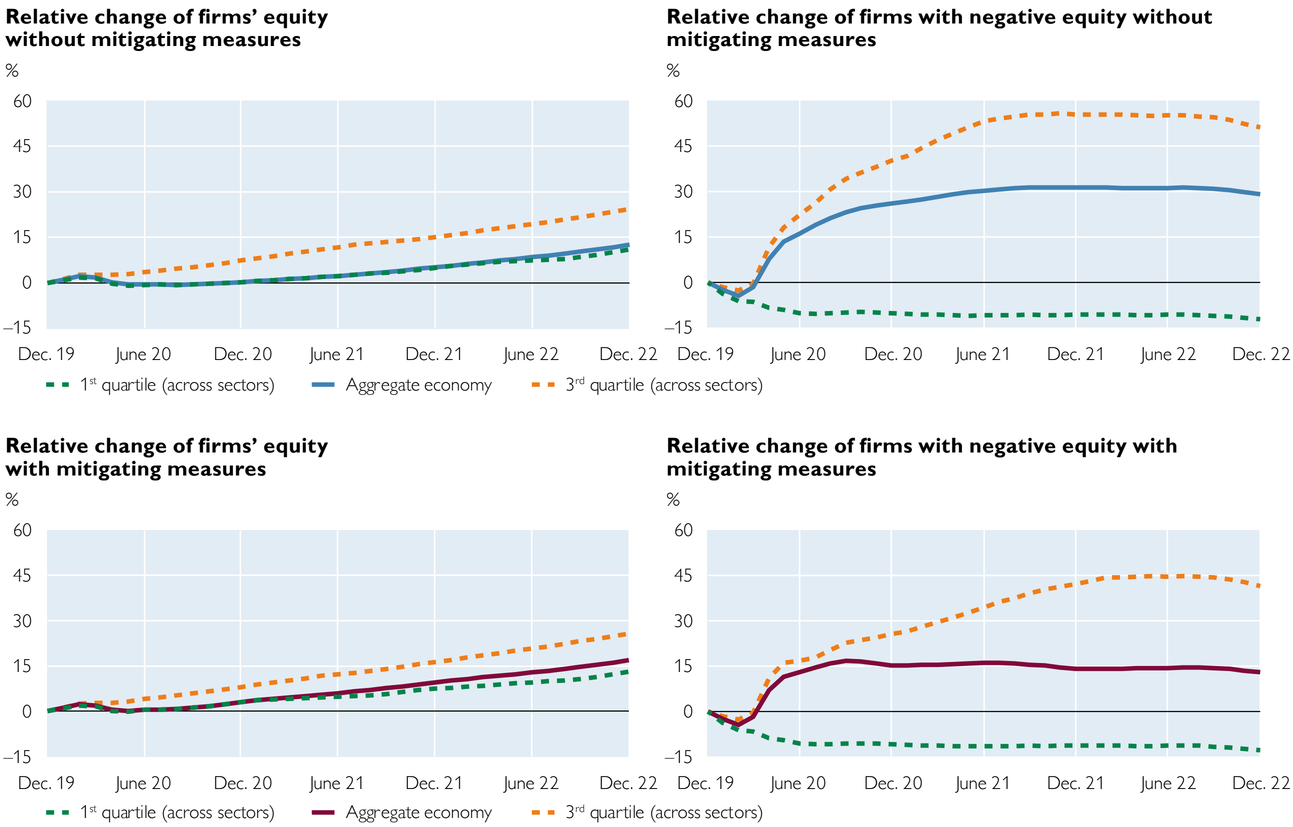
So, what drives the results in our model? As described in section 3, the stylized profit and loss statement of simulated firms is at the core of the corporate insolvency model. To understand aggregate dynamics, it is therefore useful to look at the impact on the profitability of modeled firms. Due to the static balance sheet assumption (meaning no investments over time), a good measure to investigate the impact of firms' profitability is their capitalization. To this end, recall that all after-tax profits are simply added to the equity position (or subtracted in case of a loss). The left-hand panels in chart 4 show that, on aggregate under both scenarios (without and with mitigating measures), firms' equity grows by 12.5% without and by 17.0% with mitigating measures until end-2022. Dispersion measures show a similar dynamic across sectors (except for accommodation and food service activities (NACE I) as well as arts, entertainment and recreation (NACE R) – for details, see section 6.1).

This perspective on positive aggregate profitability/aggregate capitalization, however, only tells half of the story. The right-hand panels in chart 4 show that the number of undercapitalized firms increases significantly despite an aggregate increase in capital: in the scenario without mitigating measures, by almost one-third, and with mitigating measures by up to 15.0%. Moreover, a much higher dispersion of results is visible even when we leave out the hardest-hit sectors. Undercapitalized firms increase by roughly one-half (somewhat less with measures, a little more without, see the orange lines, which represent the 3rd quartile in the right hand panels, i.e. the fifth hardest hit sector). Other sectors are barely hit by the pandemic. Despite COVID-19 and even without mitigating measures, the share of undercapitalized firms decreases (see the green lines, which represent the 1st quartile, i.e. the fifth least hit sector).

In section 6.1, we discuss the contributions to these results by economic sector and by individual measure to shed more light on the insolvency dynamic and the impact of mitigating measures in our model. But before we turn to that, we want to present the last important driver of our results. While profitability and its impact on firms' capitalization is at the core of the underlying dynamic, insolvencies are mostly driven by illiquidity. Chart 5 shows the aggregate insolvency rate

Chart 4

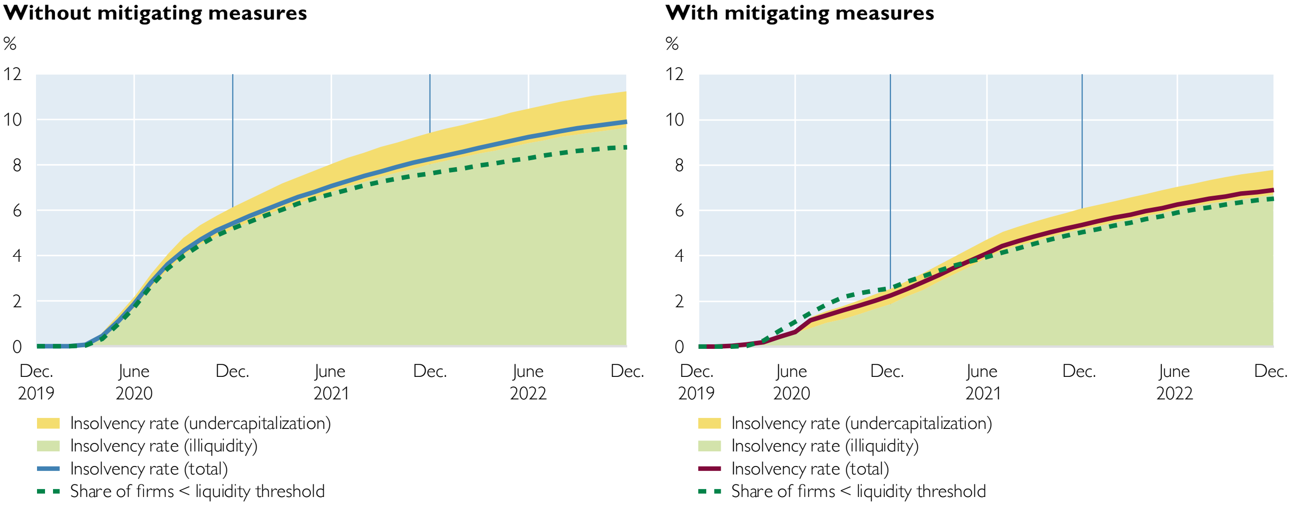
COVID-19 impact on Austrian firms' capitalization



Source: Authors' calculations.

Chart 5

Impact of COVID-19 and mitigating measures on Austrian firms' liquidity



Source: Authors' calculations.

(blue line on the left hand side without mitigating measures, red line on the right hand side with mitigating measures) and the corresponding share of firms that fail to meet the liquidity threshold (green dotted lines in both panels). Moreover, the surfaces show the share of firms that become insolvent due to liquidity constraints (light green) and due to capital constraints (light yellow). Note that there is indeed some overlap; hence, the aggregate insolvency rate lies above the liquidity and below the liquidity plus solvency share.

Three issues are noteworthy. First, in either scenario, liquidity constraints drive more than 90% of the modeled insolvency rates across sectors. Second, in the scenario without measures (left panel of chart 5), the share of firms that falls below the liquidity threshold of all insolvent firms at end-2022 is substantially lower compared with the scenario with mitigating measures (right panel of chart 5). Third, this is, among other things, due to measures that allow firms to earn their way out of the liquidity constraint (particularly the filing moratorium), as evidenced in the green dotted line's placement above the blue line on the right hand panel. In other words, not every firm that fails to meet the threshold becomes insolvent, and by the time insolvencies are again enforced, such firms are indeed no longer insolvent.

6.1 Impact on individual sectors

There are huge differences between the various sectors of the economy. Table 2 shows that two sectors stand out, namely accommodation and food service activities (NACE I) and arts, entertainment and recreation (NACE R). Without mitigating measures, 35% of the firms in each sector would become insolvent in 2020, and approximately 45% by end-2022. Mitigating measures help bring down insolvency rates to 12% in 2020 for both sectors, and to under 20% by end-2022, thus preventing two-thirds of insolvencies in the short term and about half of them in the medium term. Other sectors are substantially less hard hit.

Table 1

Cumulative annual insolvency rates

Insolvency rates	KSV average	Without mitigating measures			With mitigating measures		
	2017–2019	2020	2021	2022	2020	2021	2022
	%						
Total	1.0	5.8	8.2	9.9	2.1	5.2	6.9
Agriculture, forestry and fishing (A)	0.2	0.9	2.5	3.7	0.0	1.9	3.0
Mining and quarrying (B)	0.5	0.5	1.1	1.7	0.5	1.1	1.7
Manufacturing (C)	0.7	4.0	7.2	9.0	1.6	5.4	7.2
Electricity, gas, steam and air conditioning supply (D)	0.3	0.7	1.3	2.1	0.7	1.3	2.0
Water supply and sewerage (E)	0.7	1.5	3.7	6.6	1.4	3.5	6.3
Construction (F)	2.0	2.4	7.3	12.9	2.3	6.5	11.8
Trade (G)	1.0	6.8	9.6	11.0	2.1	7.5	9.2
Transportation and storage (H)	2.6	2.7	5.4	8.1	2.6	5.2	7.9
Accommodation and food service activities (I)	2.0	35.5	38.3	39.5	12.3	17.4	19.6
Information and communication (J)	0.6	1.4	2.4	3.2	1.3	2.3	3.1
Real estate activities (L)	0.3	0.7	1.5	2.3	0.0	1.5	2.3
Professional, scientific and technical activities (M)	0.5	0.6	1.3	2.1	0.4	1.0	1.7
Administrative and support service activities (N)	1.6	2.8	5.2	7.2	1.6	4.8	6.9
Education (P)	0.4	0.4	1.0	1.6	0.3	0.8	1.2
Human health and social work activities (Q)	0.4	0.5	1.9	3.1	0.0	0.0	0.3
Arts, entertainment and recreation (R)	0.6	36.7	42.1	42.5	12.4	16.7	18.0
Other service activities (S)	0.7	2.5	5.8	7.6	1.2	4.7	6.5

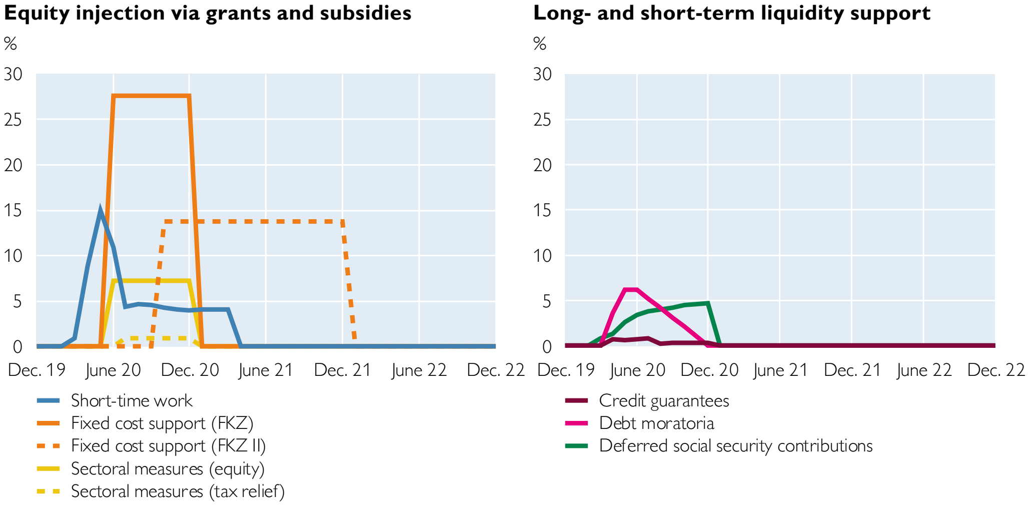
Source: KSV1870, authors' calculations.

6.2 Impact of the mitigating measures

As we have seen above, mitigating measures can only partly offset the COVID-19-induced shock to Austrian firms. In this subsection, we will delve into individual measures. In chart 6, we present the share of firms of the aggregate economy that make use of a measure in our model at any observation interval. Note that some measures have already been calibrated to actual use via reports available at the OeNB as on the cutoff date of August 31, 2020 (e.g. short-time work, credit guarantees and debt moratoria), while others are calibrated to maximum use given eligibility criteria and endowment (e.g. fixed cost grants, sector-specific measures and deferred social security contributions). In general, the use of measures declined where reporting data became available; certainly, the share of firms decreased, but also – albeit to a lesser degree – the euro amount disbursed.

Chart 6

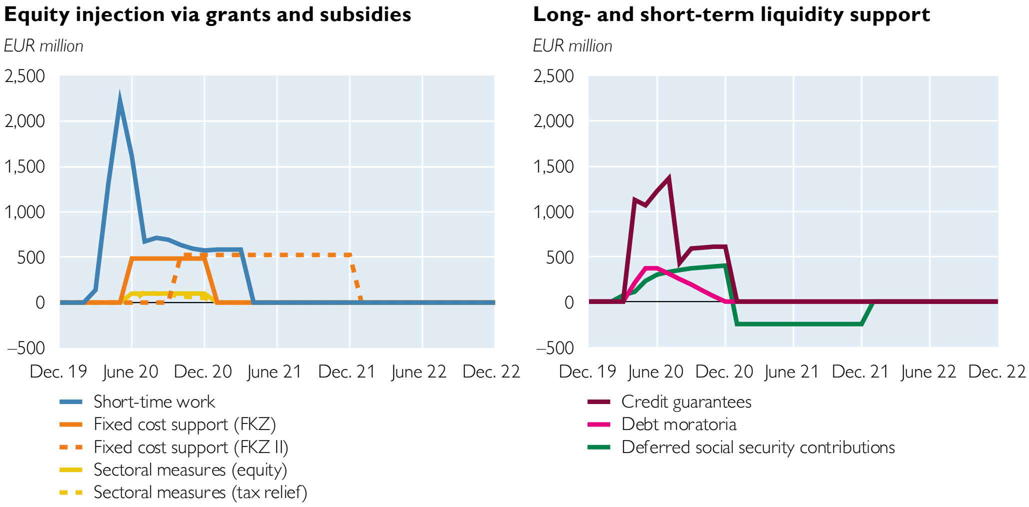
Share of Austrian firms with access to mitigating measures



Source: Authors' calculations.

Chart 7

Impact of mitigating measures on Austrian firms (monthly data)

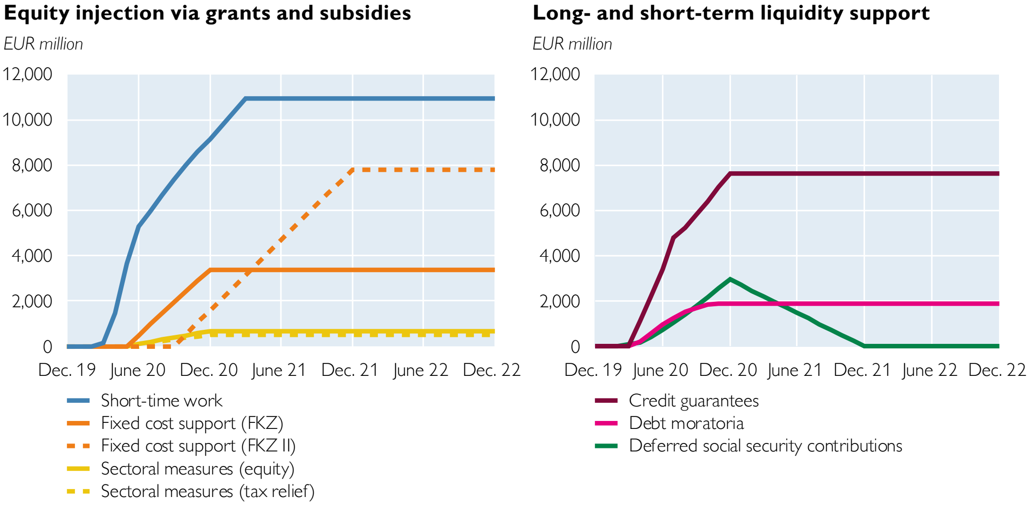


Source: Authors' calculations.

In chart 7, we show the corresponding cash flows. Combining the results in chart 6 with those in chart 7, it is self-evident that the average payout per firm vastly differs from measure to measure. For example, fixed cost grants are used by twice as many firms as short-time work, but the payouts are about the same for both measures. Another noteworthy feature shown in chart 7 is the impact of short-term liquidity measures. The green line in the right panel of chart 7 first shows a positive contribution (when payments are deferred) and a negative contribution in 2021 (once deferred payments need to be paid back). This is the driver of the effect also shown in chart 3.

Chart 8

Cumulative impact of mitigating measures on Austrian firms



Source: Authors' calculations.

Chart 8 illustrates the cumulated cash flows over time. We can see the persistence of equity injections via grants and subsidies as well as of long-term liquidity measures. Put differently, they do not recede over the course of our modeling horizon. By contrast, social security contributions are paid back slowly during the course of 2021 (green line).

Next, we look at the effects of the individual measures on insolvency rates. The first three columns of table 2 show the annual insolvency rates and the annual impact of the mitigating measures. Columns 4–6 show the cumulative results. The first two rows show the insolvency rates of all Austrian incorporated firms at the end of 2020, 2021 and 2022, without and with mitigating measures. The third row shows the combined impact of all measures. To assess the impact of each individual measure, we run the model with only this measure in place. Since many firms profit from two or more measures simultaneously, the sum of the impact of the individual measures is larger (–4.9 percentage points in 2020) than the combined effect, when all measures are in place simultaneously (–3.5 percentage points). Note that this picture reverses in 2021, since the phaseout of some measures leads to a stronger impact on annual insolvency rates with measures (1.8%) than without measures (0.5%).

Table 2

Impact of individual mitigating measures on Austrian firms' insolvency rates

	Annual insolvency rates			Cumulative insolvency rates		
	2020	2021	2022	2020	2021	2022
	Insolvency rates in %; contributions to the reduction of insolvency rates in percentage points					
COVID-19 shock without mitigating measures	5.8	2.4	1.7	5.8	8.2	9.9
COVID-19 shock with mitigating measures	2.1	3.1	1.7	2.1	5.2	6.9
Combined effects	–3.7	0.7	0.0	–3.7	–3.0	–3.0
Sum of marginal effects	–5.1	2.2	0.0	–5.1	–3.1	–3.1
Marginal effects of individual measures						
Capital injections via grants and subsidies	–1.7	–0.5	0.0	–1.7	–2.1	–2.0
Fixed cost support (FKZ)	–0.6	0.0	0.0	–0.6	–0.6	–0.5
Fixed cost support (FKZ II)	–0.3	–0.5	0.0	–0.3	–0.8	–0.7
Short-time work	–0.4	–0.0	0.0	–0.4	–0.4	–0.4
Sector-specific measures	–0.3	0.0	0.0	–0.3	–0.3	–0.3
Long-term delay of payment obligations	–0.6	–0.3	0.0	–0.6	–0.8	–0.9
Credit guarantees	–0.4	–0.4	0.0	–0.4	–0.7	–0.8
Debt moratoria	–0.2	0.1	0.0	–0.2	–0.1	–0.1
Short-term deferral of payment obligations	–2.8	3.0	0.0	–2.8	–0.2	–0.2
Filing moratorium	–1.9	2.1	0.0	–1.9	–0.0	–0.0
Deferral of social security contributions	–0.9	0.8	0.0	–0.9	–0.1	–0.1
Changes to the insolvency regime	–0.0	0.0	0.0	–0.0	–0.0	–0.0

Source: Authors' calculations.

In the short term, i.e. in 2020, short-term deferrals of payment obligations in general and the filing moratorium in particular have the strongest effect on insolvency rates (–2.8 percentage points). These measures clearly far outweigh the impact of long-term liquidity measures and equity injections via grants and subsidies.

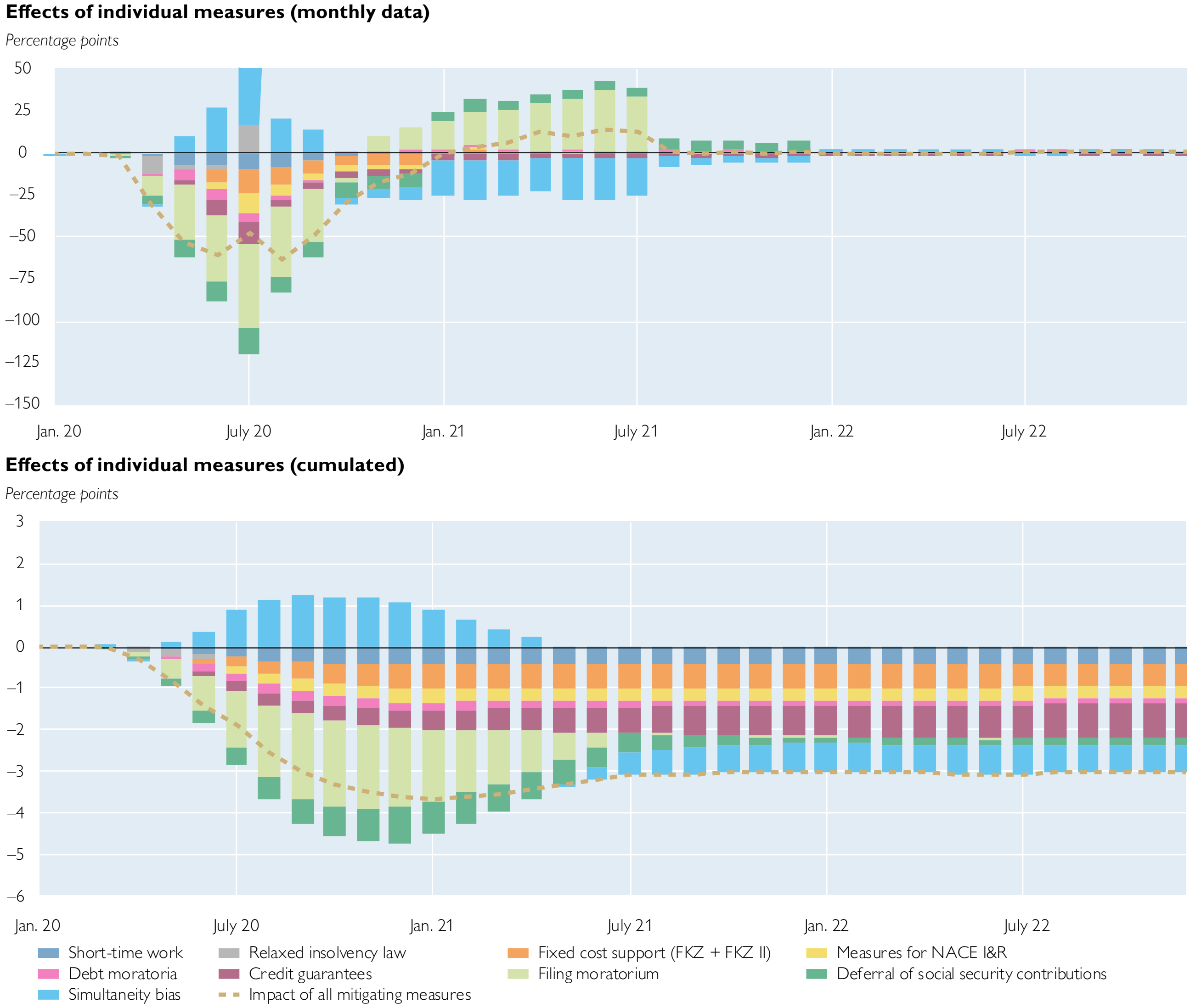
However, as liquidity support is reversed (e.g. deferred social security contributions need to be paid eventually), the picture changes dramatically. At the end of 2022, credit guarantees and short-time work appear to be the most effective measures across sectors, while fixed cost grants play an important role in the hardest-hit sectors (arts, entertainment and recreation (NACE R) and accommodation and food service activities (NACE I)).

Another observation, not captured in table 2 or in the charts, is an artifact related to credit guarantees. While not covering many of the most affected firms due to eligibility constraints, credit guarantees appear to be very effective and cost efficient, providing liquidity support for firms in the months when shocks are highest. Survival rates of firms that availed themselves of credit guarantees turn out to be very high even in the most affected sectors (and at least until the end of the observation period). Moreover, the medium-term impact of credit guarantees is indeed highest across all measures, and this measure is also cost efficient. To sum up these findings, we present the aggregate picture in chart 9, first on a quarterly basis (left panel), then on a cumulative basis (right panel).

All support measures notwithstanding, while many firms can avoid bankruptcy in the model, many cannot rebuild their capital reserves and survive with a weaker balance sheet (see also chart 4). This is of particular importance in light of two opposing arguments related to credit guarantees. On the one hand, credit guarantees appear to generate by far the highest marginal impact of all measures for our

Chart 9

Impact of COVID-19 and individual mitigating measures on Austrian firms' insolvency rates



Source: Authors' calculations.

observation period until end-2022. Given that they are also cost efficient compared to equity injections via grants or subsidies, we conclude that they are not only the most effective measure but also the most efficient in terms of their cost to the Austrian government. On the other hand, and admittedly outside the scope of our model and therefore this paper, debt overhang will almost certainly prove a challenge for some firms once credit extended with guarantees becomes due. This issue certainly merits further investigation.

7 Summary and conclusions

The final section tries to do justice to the twofold nature of our paper. On the one hand, we introduced a novel approach for modeling corporate insolvencies in Austria, and on the other, we also presented results of this model. Hence, we start out with important disclaimers regarding the new modeling approach with a view to providing guidance as to the interpretation of the model results presented here. We conclude the paper by identifying next steps that we have in mind going forward.

7.1 Important disclaimers

The macroeconomic forecast is subject to a high degree of uncertainty. There are substantial downside risks and, at the time of writing, a renewed increase of COVID-19 infections was well underway and eventually materialized. After the cut-off date of the study, the Austrian government has decided to impose further lockdowns in Q4 2020 and Q1 2021. At the same time, the macroeconomic impact seems to be much lower than in spring 2020.

The corporate insolvency model is highly stylized and relies on several heroic assumptions. Balance sheets are static (no structural changes/no growth/no investments) and no new firms are incorporated over the horizon of the projection. While balance sheet and profit and loss statement breakdowns are drawn from the multivariate distribution, subitems reflect the relative size of the sectoral means. Moreover, a single draw from the distribution determines how profitably a firm conducts its business over the entire projection horizon. In a similarly crude manner, we calibrate elasticities – i.e. firms' ability to reduce fixed costs – at an aggregate sector-specific or economy-wide level; here, we would certainly benefit from further investigation. In a similar vein, the link between solvency and liquidity is too mechanistic due to an oversimplified role banks play rolling over corporate credit. This also restricts the mitigating measures that firms facing a liquidity crunch can take by themselves. Overall, the calibration of the model probably errs on the conservative side.

The effects of the mitigating measures are also subject to considerable uncertainty. On the one hand, they could be overestimated, since we assume a quick payout of funds based on the eligibility criteria. Delays in application and/or payment would certainly lead to higher insolvency rates and thus make measures less effective. On the other hand, the measures could reduce insolvencies more strongly than assumed due to possible impacts on GDP growth. We based the insolvency rate projection with and without mitigating measures on the same macroeconomic scenario. This can be justified since the mitigating measures are not designed as economic stimulus packages but aim at maintaining the solvency and/or liquidity of the corporate sector. Hence, they do not lead to an increase in demand and thus in production (except for some sector-specific packages). While this holds in the short term (during lockdown and initial easing phase), in the longer term, a scenario without mitigating measures and more insolvencies would negatively impact GDP via production linkages and confidence effects. This would trigger a feedback loop with higher insolvencies. Hence, the effects of the mitigating measures could be even higher than reported.

In light of these important qualifiers, a healthy distrust of absolute results – mainly the projected insolvency rates – should, however, not diminish the valuable structural insights our model provides. While mitigating measures can only partly offset the COVID-19-induced shock to Austrian firms, they play an important role in lowering insolvency rates on aggregate and in the hardest-hit sectors.

It is important to note, however, that their impact is more pronounced in 2020, due to the short-term deferral of payment obligations that is part of some measures. Consequently, insolvency rates will be higher in 2021 with mitigating measures than without, but they will not reach their cumulated level.

Long-term liquidity support is much harder to assess. Of all measures, credit guarantees in particular appear to have the highest marginal impact in our observation period until end-2022. However, as mentioned above, many firms cannot rebuild their capital reserves and survive with a weaker balance sheet. While it is outside the scope of our model and therefore also this paper, this issue would merit further investigation.

Finally, equity injections via grants and subsidies provide at best a mixed story of success. Short-time work and fixed cost grants, which are the second and third most effective measures in our model for the entire observation horizon, have a rather limited impact compared to their cost to the Austrian government. The more than EUR 20 billion distributed to firms with few strings attached drive down the aggregate insolvency rate by 1 percentage point. While short-time work is arguably a measure with objectives beyond the support of firms, this does not apply to other grants and subsidies in the same way. Given that firms' illiquidity turned out to be the main driver of insolvencies according to our results, the question remains whether more cost-efficient alternatives in form of further medium- or long-term liquidity support could not have yielded better results at a lesser cost.

7.2 Next steps

Within the current framework, i.e. without addressing the above weaknesses, the most important refinement relates to the recalibration of the mitigating measures included in the model as more empirical data become available. For instance, data on credit guarantees and debt moratoria take-up by incorporated firms are reported to the OeNB on a weekly basis. By the time this article is published, data until year-end 2020 will have become available. Also, if existing measures are extended, endowments change or further measures are put into law, our model allows for a quick integration thanks to the way it is designed. Similarly, the model allows for a simple assessment of counterfactuals. Examples are the integration of frictions with regard to the payout of existing mitigating measures, the recalibration of existing or introduction of additional measures that are not (yet) on the table. Since its first iteration in June 2020, the model has been re-run multiple times to inform internal policy debates.

Beyond the current framework, i.e. when we address the above weaknesses, we see multiple avenues to improve the model. Most importantly, the static balance sheet assumption currently limits the conclusions that can be drawn from our work. An enhancement in this regard would, however, rely on more realistic investment behavior of firms, as profitable firms improve their equity position throughout the observation horizon, while not expanding their business. We believe that this does not impact the lower rung of firms in or close to insolvency, but it is certainly a requirement to be able to draw broader conclusions on a sectoral level. Unfortunately, an extension of the model in this regard is not a straightforward procedure: while we currently assume passive reactions to outside circumstances, firms would have to be transformed into active agents with objective functions.

In the meantime, we can turn to low-hanging fruit to improve the model. Many of the empirical calibrations mentioned throughout the paper merit revisiting. Whenever we chose to rely on economy-wide parameters, we can move to sectoral calibrations, e.g. regarding the calibration of the elasticities of how many firms can reduce fixed costs, but also regarding sectoral differences regarding access to credit in difficult macroeconomic circumstances. Finally, further research could be put into the simulation of firms, be it the extrapolation of profit and loss subitems via sectoral means or the single draw that determines medium-term profitability. Any improvements in these areas will certainly help make our model output more realistic and therefore more valuable for the policy discussions it was initially designed to enlighten.

Finally, we want to mention that we use our insolvency model together with the OeNB's top-down stress testing framework ARNIE to assess the impact of the COVID-19 pandemic on the banking system (see Guth et al., 2020). Rather than employing large-scale regression models to derive risk parameters for credit risk, we infer default probabilities of banks' credit exposure from our results described above. For nondomestic exposures of the Austrian banking system, we extrapolate insolvency rates based on the assumptions that individual sectors face similar challenges across countries and that the overall severity with which individual countries are affected by the pandemic is reflected in country-specific GDP forecasts. To this end, we utilize GDP forecasts by the European Central Bank (ECB) for other countries/country aggregates to calculate scaling factors based on the relative GDP-level deviation.

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Annex 1: Tables

Table A1

Value-added effects for NACE 1 sectors

	2020	2021	2022
	Deviation from pre-crisis trend		
Total	–9.7	–7.2	–5.6
Agriculture, forestry and fishing (A)	–3.3	–4.5	–2.9
Mining and quarrying (B)	–7.0	–7.3	–6.6
Manufacturing (C)	–12.0	–10.5	–8.9
Electricity, gas, steam and air conditioning supply (D)	–9.2	–8.3	–7.0
Water supply and sewerage (E)	–6.7	–6.2	–5.3
Construction (F)	–7.4	–8.3	–7.2
Trade (G)	–11.7	–8.2	–6.3
Transportation and storage (H)	–8.8	–6.2	–5.3
Accommodation and food service activities (I)	–43.1	–14.9	–7.1
Information and communication (J)	–7.5	–4.8	–3.7
Real estate activities (L)	–4.9	–6.3	–5.4
Professional, scientific and technical activities (M)	–9.2	–7.1	–6.0
Administrative and support service activities (N)	–7.5	–5.5	–4.1
Education (P)	–0.2	–2.6	–2.4
Human health and social work activities (Q)	–1.6	–3.6	–3.0
Arts, entertainment and recreation (R)	–45.6	–16.8	–8.3
Other service activities (S)	–10.6	–10.2	–7.0

Source: OeNB.

Table A2

Elasticities with respect to changes in turnover[1]

	I5 Cost of goods sold, materials and consumables	I6 External supplies and services	I7 Staff costs[2]				I81 Operating taxes and other operating charges	I83 Financial expenses	I9 Depreciation	I10 Interest expenses	I11 Taxes on profits
			Layoffs	Short-time work	Total without short-time work[2]	Total with short-time work					
Elasticities with respect to changes in turnover											
Agriculture, forestry and fishing (A)	0.90	0.50	0.64	0.55	1.19	0.92	0.00	0.00	0.00	0.00	1.00
Mining and quarrying (B)	0.90	0.50	0.38	0.54	0.92	0.65	0.00	0.00	0.00	0.00	1.00
Manufacturing (C)	0.90	0.50	0.10	0.92	1.02	0.56	0.00	0.00	0.00	0.00	1.00
Electricity, gas, steam and air conditioning supply (D)	0.90	0.50	0.02	0.15	0.17	0.10	0.00	0.00	0.00	0.00	1.00
Water supply and sewerage (E)	0.90	0.50	0.28	0.57	0.85	0.56	0.00	0.00	0.00	0.00	1.00
Construction (F)	0.90	0.50	0.68	0.58	1.26	0.97	0.00	0.00	0.00	0.00	1.00
Trade (G)	0.90	0.50	0.20	0.88	1.09	0.64	0.00	0.00	0.00	0.00	1.00
Transportation and storage (H)	0.90	0.50	0.43	0.70	1.13	0.78	0.00	0.00	0.00	0.00	1.00
Accommodation and food service activities (I)	0.90	0.50	0.35	0.26	0.61	0.48	0.00	0.00	0.00	0.00	1.00
Information and communication (J)	0.90	0.50	0.18	0.58	0.75	0.47	0.00	0.00	0.00	0.00	1.00
Real estate activities (L)	0.90	0.50	0.64	0.67	1.31	0.97	0.00	0.00	0.00	0.00	1.00
Professional, scientific and technical activities (M)	0.90	0.50	0.19	0.70	0.89	0.54	0.00	0.00	0.00	0.00	1.00
Administrative and support service activities (N)	0.90	0.50	0.90	0.80	1.70	1.30	0.00	0.00	0.00	0.00	1.00
Education (P)	0.90	0.50	0.20	0.00	0.20	0.20	0.00	0.00	0.00	0.00	1.00
Human health and social work activities (Q)	0.90	0.50	0.90	0.00	0.90	0.90	0.00	0.00	0.00	0.00	1.00
Arts, entertainment and recreation (R)	0.90	0.50	0.11	0.42	0.53	0.32	0.00	0.00	0.00	0.00	1.00

Source: Authors' assumptions.

[1] *These elasticities describe the percentage response of firms' cost components relative to the percentage drop in turnover.*
[2] *In the scenario without short-time work, we assumed that firms lay off 50% of the workers for whom they applied for short-time work.*

Table A3

Description of the variables of the firm-level dataset

Source	BACH code	Short description	Long description
SABINA	A7	Cash and bank ratio	Includes the amount available in cash, demand deposits and other deposits in financial institutions.
SABINA	E	Equity ratio	Total equity
BACH	R13	Current assets	Ratio of current assets (A2+A3+A41+A51+A6+A7) to total assets (A)
BACH	R16	Current liabilities	Ratio of current debt (L11+L21+L311+L321+L4+L5) to total balance sheet (A)
BACH	A6	Current financial assets	Includes financial assets held for trading and derivatives.
BACH	L21	Current bank debt	Amounts owed to credit institutions due to be settled within 12 months after the reporting period
BACH	I1	Turnover	Includes sales of goods and services net of returns, deductions and rebates. Sales include sales of goods and services net of returns, deductions and rebates. Sales are net of VAT and excise taxes.
BACH	I42	Financial income	Details of other income relating to financial income
BACH	It1	Total income	I1+I2+I3+I4
BACH	I5	Cost of goods sold, materials and consumables	Sum of costs for raw, auxiliary and operating materials, purchased goods and services
BACH	I6	External supplies and services	Expenses for services rendered by third parties that directly serve to provide own services and for other areas of the company (outside of production), for expenses incurred for purchased services (e.g. maintenance of plants and buildings), provided material consumption predominates; this also applies to expenses for the consumption of energy and water or waste disposal services.
BACH	I7	Staff costs	Wages, salaries and social contributions (expenses for severance payments and benefits to company employee pension funds, expenses for retirement benefits, expenses for statutory social security contributions as well as taxes and compulsory contributions dependent on remuneration)
BACH	I81	Operating taxes and other operating charges	Includes expenses that do not require separate disclosure, such as taxes (excluding taxes on income and profits), administrative expenses, sales expenses and operating expenses (e.g. transport costs, consulting expenses, rent, telephone, energy).
BACH	I83	Financial expenses	Expenses from financial assets and from securities held as current assets (e.g. correction of shares held by the company)
BACH	I9	Depreciation	Depreciation of intangible assets and property, plant and equipment as well as capitalized expenses for the start-up and expansion of a business
BACH	I10	Interest expenses	Interest payments for bank loans, bank overdraft and supplier credit
BACH	I8	Other expenses	Depreciation of current assets, insofar as these exceed the depreciation customary in the company and items I81 and I83.
BACH	It2	Total expenses	Sum of all expenses; consists of positions I5 + I6 + I7 + I8 + I9 + I10 + I11 (I11 = tax on profits).

Source: BACH and SABINA databases, authors' compilation.

Table A4

Statistics of equity and cash and bank ratios from the SABINA database (2018)

	Equity ratio							Cash and bank					Number of firms	Average size of balance sheet (EUR thousand)
					Share of firms with equity ratio							Share of firms with		
	Mean	1st quartile	Median	3rd quartile	<-100%	<–30%	<0	Mean	1st quartile	Median	3rd quartile	Cash and bank < 0		
TOTAL	39.9	8.7	37.7	71.1	5.4	9.9	17.4	7.7	1.8	9.9	32.9	2.5	129,239	5,506
A	55.5	6.1	29.5	63.3	3.1	7.6	16.2	6.7	1.6	5.4	19.4	0.1	956	2,549
B	50.3	16.4	42.1	70.0	6.2	10.1	14.4	2.4	–0.9	3.8	20.9	35.0	303	20,774
C	45.9	15.1	39.2	66.5	4.5	8.8	14.0	6.8	1.4	7.7	25.6	0.1	10,981	14,402
D	36.1	2.7	18.8	50.5	2.5	6.8	20.9	3.4	0.9	3.7	13.4	0.2	1,527	33,016
E	32.1	16.7	40.5	67.6	3.6	6.1	11.6	4.5	–0.5	6.2	25.4	28.0	621	7,585
F	31.4	10.8	36.1	64.9	3.2	6.8	14.2	11.7	1.5	9.5	29.0	0.1	15,648	2,426
G	42.7	11.1	38.4	69.5	6.8	12.0	17.8	10.0	2.0	10.3	31.6	0.1	27,337	4,067
H	32.7	6.3	29.2	58.4	4.9	10.6	19.6	5.6	2.1	9.8	26.6	0.2	4,672	10,631
I	26.3	–14.9	19.2	51.5	11.0	20.4	32.1	8.5	2.4	8.2	24.7	0.2	8,782	1,984
J	44.6	14.2	49.3	77.3	8.4	12.9	17.6	13.9	7.0	26.5	55.2	0.1	7,877	2,815
L	38.8	2.3	24.6	73.7	2.8	5.8	19.4	4.9	0.4	3.0	14.8	13.7	21,261	7,674
M w.o. 70100	49.5	25.9	58.3	83.9	4.2	6.9	10.4	17.5	4.5	20.1	47.9	0.1	18,427	1,537
N	27.5	10.7	36.3	67.0	5.6	10.3	16.3	8.7	3.9	16.3	41.9	0.2	5,505	5,059
PQ	30.9	9.4	37.4	70.6	6.7	12.1	18.2	17.9	3.6	17.2	45.2	0.1	2,287	1,805
RS	28.8	–8.2	29.1	65.3	11.2	19.4	28.4	16.0	2.3	11.2	34.4	0.2	3,055	2,410

Source: SABINA database, authors' compilation.

Annex 2: Equations of the insolvency model

A) Model without mitigating measures

Profit P of firm i in sector n at time t is calculated as total income $I^{t,n,i}$ minus total costs $C^{t,n,i}$. Total revenues $I^{t,n,i}$ are the sum of turnover $TO^{t,n,i}$ and financial income $FI^{t,n,i}$. We considered eight cost components $C_m^{t,n,i}$ in our analysis (cost of inputs, external inputs, staff costs, operating charges, financial expenses, interest expenses, depreciation and other expenses).

$$P^{t,n,i} = I^{t,n,i} - C^{t,n,i} = TO^{t,n,i} + FI^{t,n,i} - \sum_{m=1}^{M} C_m^{t,n,i} \quad (1)$$

Turnover in period t is calculated by multiplying pre-pandemic turnover $TO^{0,n,i}$ by 1 minus the relative shock size the firm faces. To obtain the shock size $\sigma^{t,n,i}$ for firm i in sector n, we assumed that the distribution of the sectoral macroeconomic shock over firms follows a normal distribution.

$$TO^{t,n,i} = TO^{0,n,i}(1 - \sigma^{t,n,i}) \quad (2)$$

For financial income $FI^{t,n,i}$, we assumed that it follows the development of turnover.

$$FI^{t,n,i} = FI^{0,n,i}(1 - \sigma^{t,n,i}) \quad (3)$$

The cost components are obtained in a similar way by multiplying the shock to turnover by the response elasticities of the respective cost components.

$$C^{t,n,i} = \sum_{m=1}^{M} C_m^{0,n,i}(1 - \sigma^{t,n,i}\varepsilon_m^n) \quad (4)$$

Positive profits are taxed with the corporate income tax rate cit.

$$P^{t,n,i} = P^{t,n,i}(1 - cit) \quad (5)$$

Each firm's equity position is updated by adding the profit in period t to the equity position of the previous period t-1.

$$E^{t,n,i} = E^{t-1,n,i} + P^{t,n,i} \quad (6)$$

The cash flow from operating activities $CF_{op}^{t,n,i}$ is calculated via the indirect method by subtracting debt repayment $DR^{t,n,i}$ (our sole source of financial expenses) and adding depreciation $DE^{t,n,i}$. Due to the *static balance sheet assumption,* we do not consider *capitalized production* or similar changes to the balance sheet in our cash flow calculation.

$$CF_{op}^{t,n,i} = P^{t,n,i} - CP^{t,n,i} - DR^{t,n,i} + DE^{t,n,i} \quad (7)$$

Again, due to the *static balance sheet assumption,* the cash flow after refinancing activities $CF_{fin}^{t,n,i}$ only considers bank refinancing of already existing debt $D^{t,n,i}$. Banks refinance existing debt minus the share of principal repayment α only if a bank's equity $E^{t,n,i}$ is positive. If it is negative, firm $F^{t,n,i}$ can only make use of undrawn credit lines, expressed as the share of its debt β.

$$CF_{fin}^{t,n,i} = \begin{cases} if\ E^{t,n,i} \geq 0 & CF_{op}^{t,n,i} - \alpha D^{t,n,i} \\ if\ E^{t,n,i} < 0 & CF_{op}^{t,n,i} - (1-\beta) D^{t,n,i} \end{cases} \tag{8}$$

Again, due to the *static balance sheet assumption,* firms do not invest. Therefore, for most firms the cash flow after investments $CF^{t,n,i}$ (the actual cash flow in period t) equals the cash flow after refinancing activities $CF_{fin}{}^{t,n,i}$. However, firms with a negative cash flow after refinancing activities $CF_{fin}{}^{t,n,i}$ in period t are allowed to disinvest by fire-selling financial assets $FA^{t,n,i}$. We assume that this is possible at book value, i.e. without the application of a haircut. Obviously, firms can divest only once.

$$CF^{t,n,i} = \begin{cases} if\ CF_{fin}^{t,n,i} \geq 0 & CF_{op}^{t,n,i} \\ if\ CF_{fin}^{t,n,i} < 0 & CF_{op}^{t,n,i} + FA^{t,n,i} \end{cases} \tag{9}$$

The liquidity position of each firm $L^{t,n,i}$ is updated by adding the cash flow (after investments) $CF^{t,n,i}$ in period t to the liquidity position ("cash and bank") of the previous period t-1.

$$L^{t,n,i} = L^{t-1,n,i} + CF^{t,n,i} \tag{10}$$

A firm i in sector n becomes overindebted, i.e. insolvent, in period t if its equity ratio $E^{t,n,i}$ falls below –30%.

$$I_E^{t,n,i} = \begin{cases} if\ E^{t,n,i} \geq -30\% & 0 \\ if\ E^{t,n,i} < -30\% & 1 \end{cases} \tag{11}$$

The firm becomes illiquid if its liquidity ratio $L^{t,n,i}$ falls below –10%.

$$I_L^{t,n,i} = \begin{cases} if\ L^{t,n,i} \geq -10\% & 0 \\ if\ L^{t,n,i} < -10\% & 1 \end{cases} \tag{12}$$

The firm becomes bankrupt if it is either insolvent or illiquid.

$$I_{tot}^{t,n,i} = \begin{cases} if\ F_{Ins\,(E)}^{t,n,i} = 1 & 1 \\ elseif\ F_{Ins\,(L)}^{t,n,i} = 1 & 1 \\ else & 0 \end{cases} \tag{13}$$

B) Model with mitigating measures

The structure of the model with mitigating measures basically equals the structure of the model without these measures. Therefore, we just present the equations that include the measures. For this purpose, we classify mitigating measures according to their impact into *profit-related mitigating measures, cash flow-related mitigating measures and mitigating measures that suspend the filing for bankruptcy.* For the sake of simplicity, we refrain from presenting the implementation details of the mitigating measures in algebraic form.

Profit-related mitigating measures $MM_P{}^{t,n,i}$ include the fixed cost support, short-time work and sector-specific measures (equity injection for NACE I and decrease of value-added tax for NACE I and NACE R). The debt moratorium impacts on profits via deferred interest payments. These measures have a direct impact on firms' equity position. Note that all profit-related measures also impact on the cash flow and hence the liquidity position of firm *i*.

$$E^{t,n,i} = E^{t-1,n,i} + P^{t,n,i} + MM_P^{t,n,i} \quad (6)$$

In addition to profit-related measures, the liquidity position of firm *i* also depends on *cash flow-related mitigating measures* $MM_{CF}{}^{t,n,i}$ (credit guarantees, deferral of social security contributions and the deferral of the principal from the debt moratorium).

$$L^{t,n,i} = L^{t-1,n,i} + CF^{t,n,i} + MM_{CF}^{t,n,i} \quad (10)$$

In addition to profit- and cash flow-related *measures there are measures that suspend the filing for bankruptcy.* The relaxed insolvency law suspends firms' obligation to apply for bankruptcy in case of overindebtedness. Hence, the insolvency variable $I_E{}^{t,n,i}$ is set to zero for all firms.

$$I_E^{t,n,i} = 0 \quad (11)$$

The filing moratorium granted by health insurance providers and tax authorities directly impacts on the liquidity variable $I_L{}^{t,n,i}$. In normal times, half of all filings for bankruptcy due to illiquidity come from these two institutions, which is why we randomly draw from a uniform distribution between 0 and 1 and retain a firm as illiquid if the draw is below 0.5.

$$I_L^{t,n,i} = I_L^{t,n,i} * rand < 0.5 \quad (12)$$