HERTIE SCHOOL

MASTER THESIS

The effect of government support during the COVID-19 pandemic: Firm-level evidence from Germany

---

Author:
Marco SCHILDT

Supervisor:
Dr. Simon MUNZERT

A thesis submitted in fulfillment of the requirements for the degree of Master of Data Science for Public

May 2, 2023
Wordcount: 7.675

HERTIE SCHOOL

Executive Summary

Master of Data Science for Public

The effect of government support during the COVID-19 pandemic: Firm-level evidence from Germany

by Marco SCHILDT

By matching information on firm level from two sources this thesis provides insights into the effects of government support during the COVID-19 pandemic in Germany. To provide an impact assessment a quasi-experimental approach with a DiD regression is employed to estimate the causal effect of aid measures on the liquidity and solvency of companies. The results suggest that in 2020 loan-based measures supported companies by improving their liquidity by 5.3 %, while grant based aid was insufficient as a liquidity injection since beneficiaries had no improvement in liquidity and relatively higher debt. Only in 2021 grants programs became effective in providing liquidity and preserving the equity of firms. In 2021 the liquidity increase of grant beneficiaries was 7.7 %, twice as high as the effect of grants in 2021.

The analysis of insolvencies amongst aid beneficiaries suggests that they were already significantly weaker before the pandemic and that aid measures were less effective in supporting them. A sector view reveals that the most supported industries gastronomy and accommodation show below average insolvency rates, suggesting that aid measures were successful in reducing the chance of insolvency in their presumed main target sectors.

Finally, the data granularity has been exploited with a combination of generalized propensity scores and a generalized linear model (GLM) to advance the assessment from a binary to a continuous treatment perspective. Overall, the visualizations are in line with the results from the previous DiD approach and don't show any concerning abnormalities. In greater detail, the visualization reveals heterogeneity amongst beneficiaries from different industries, which connects with the observed heterogeneity in insolvencies of different industries.

Contents

List of Figures

List of Tables

List of Abbreviations

ATT	**A**verage **T**reatment Effect on the **T**reated
DiD	**D**ifference-**i**n-**D**ifferences
EU COM	**EU**ropean **COM**mission
GPS	**G**eneralized **P**ropensity **S**cores
SMEs	**S**mall and **M**edium-sized **E**nterprises

Chapter 1

Introduction to the Government Support in Germany

The Covid-19 pandemic has severely affected the entire world with many devastating consequences. Businesses in many parts of the economy were struggling to survive due to shocks in demand, lockdowns from governments, and disrupted supply chains (EU COM, 2020).

To sustain the economy and prevent businesses from bankruptcy during the pandemic, the German government responded with a range of policies. Besides the various measures like labor cost subsidies, temporary changes in the insolvency law, and tax reliefs, the financial support through grants and loans was unprecedented. Financial support was available for businesses of all sizes that were affected by the pandemic ranging from self-employed individuals to small and medium-sized enterprises (SMEs) up to very large companies. From spring 2020 to summer 2022, grants, loans, recapitalizations, and guarantees alone accounted for a total of around EUR 130 billion (BMWK, 2022).

Grants and loans were the two groups of instruments with widespread use by the German government. Grants are funds provided by the government to businesses that are not needed to be repaid. Grants are usually subject to the terms and conditions, but do not require any consideration in return. Whereas financial support measures based on loans have to be repaid, like standard bank loans. The advantage over a normal credit transaction is beneficial conditions that a company would not have received under normal circumstances from a bank, especially not in times when the company's future is uncertain and linked to the further development of the pandemic.

From the companies' point of view, both types of aid have the immediate effect of a liquidity injection, meaning that additional cash is available.

However, despite the liquidity additional debt doesn't offset the deteriorating effect of potential losses on the equity of firms. Together with the repayment obligation, loans have a contrasting effect on the solvency compared to grants which could only become relevant in the long run.

Irrespective of the concrete form of the aid measures their scale manifests a fiscal effort that is inconceivable at this magnitude under normal conditions. Usually, governments are not permitted to provide extensive subsidies, due to concerns of distorting competition in the European single market (Claici, Eymard, and Vallée, 2022). The permissibility of subsidies is comprehensively regulated by European state aid laws. Before a subsidy is considered permissible under this legal framework an assessment of its necessity, incentive effect, proportionality and effect on trade and competition is needed (Claici, Eymard, and Vallée, 2022). In light of the ongoing pandemic, the EU relaxed rules on subsidies by introducing the Temporary Framework for State aid measures to support the economy in the current COVID-19 outbreak, which provided national governments more freedom to come up with quick and extensive policy responses to support businesses (EU COM, 2020).

Under the framework, a justification of the financial support measures including necessity, the appropriateness, and proportionality to remedy the impact of the pandemic on the economy was required from the German government (EU COM, 2020). Defining and deciding on the appropriateness as well as proportionality of support measures is a complex and challenging task. Due to the unpredictable scale of the pandemic, uncertainty is immense. On the other hand, the effect of support measures is nothing trivial to estimate, given that their scale was unprecedented. To ensure that the support measures are effective and efficient, a good understanding of aid instruments is vital.

A key role of assessments is to provide this understanding. This thesis aims to access whether grants and loans were successful in providing much-needed liquidity and preventing businesses from bankruptcy.

In specific, this thesis tries to answer whether the aid measures were successful in providing liquidity, by measuring the causal effect of aid instruments on the firm liquidity. A causal effect that is more than marginal would allow to attribute the liquidity increase to the aid program and bring support for its success. In case of unmeasurable or marginal effects the injected liquidity could have been fully absorbed by aid recipients or have been generally ineffective. Questions about whether the aid was providing sufficient support would arise and, in any case, challenge the successfulness of liquidity

support through grants and loans. Considering the magnitude of government intervention and the scale of fiscal efforts aid measures are expected to have a measurable effect on firm liquidity.

Concerning the aforementioned differences between grants and loans, this work will also seek to answer whether these instruments have different effects on the solvency of aid beneficiaries. It is expected that loans increase the leverage, while grants are expected to have the opposite effect and help to preserve the equity of firms.

The analysis of liquidity and solvency will be supplemented by a view of dose response functions to provide a granular picture of the effects at different levels of aid. The insights will be used to answer whether the effects of aid are varying depending on the level of aid.

With a sectoral overview, the assumption of heterogenous effects of grants between industries with different cost structures by (Bischof et al., 2021) will be tested. Finally, this paper looks closer at aid beneficiaries that are insolvent by spring 2023 to compare the effectiveness of their aid as well as the heterogeneity assumption.

The approach differs from existing assessments in two regards. First, only publicly available data sources are used. Previous assessments of pandemic aid with a focus on Germany were only conducted based on survey data (Marek and Gärtner, 2022; Bertschek et al., 2022; Dörr, Licht, and Murmann, 2022; Bischof et al., 2021). As such, this work demonstrates a way of policy evaluation that is not reliant on surveys, which are typically time and resource intensive.

Second, an approach with generalized propensity scores is adopted, which has so far only played a role in the context of other subsidy assessments (Selebaj and Bule, 2021; Carboni, 2017). This methodology allows the estimation and visualization of dose-response functions to determine whether the causal effects support vary depending on the different sizes of the aid measures (Selebaj and Bule, 2021).

This thesis is organized as follows. After this introduction, chapter 2 provides an overview of the general effects of the COVID-19 pandemic on businesses as well as the already existing impact assessments of government support. Chapter 3 presents the data sources and chapter 4 explains the methodologies. In chapter 5, the findings about the effect of aid measures are shown. Chapter 6 addresses the policy implications and concludes.

1

[1]Supplementary code to the paper is available at https://github.com/m-schildt/AAA

Chapter 2

Literature Review

2.1 Pandemic effects

The negative consequences of the COVID-19 pandemic on the economy have become evident in many areas. Many businesses were severely affected by drops in demand and containment measures ordered by authorities (EU COM, 2020).

When business operations are halting while costs like rent or personal costs continue occurring the pandemic shock eventually leads to negative cash flows for many firms (Fernández-Cerezo et al., 2021). Depending on the affectedness of the business, the liquidity reserves will inevitably deteriorate and eventually liquidity shortfalls are inescapable with negative cash flows (Puhr and Schneider, 2021). Although the demand for liquidity is individual for every company, the overall lack of liquidity is apparent.

An early simulation study from Italy quantified the total liquidity deficit of all Italian SMEs caused by the Covid-19 shock to 83.7 billion Euros at the end of 2020 (Bellucci et al., 2022). In comparison to the Belgian corporate sector, in a scenario without policy interventions, the drop in liquidity by September 2020 was quantified at 28.2 billion Euros (Tielens, Piette, and Jonghe, 2020). Empirical results from (Tielens, Piette, and Jonghe, 2020) suggest that in Belgium even businesses that used to be profitable require a large amount of additional financing to offset their liquidity shortfall. However, evidence from Belgium also showed that the COVID-19 pandemic widened the gaps between companies with some performing than in normal times (Dhyne and Duprez, 2021).

Without a return of profits, firms are in need of liquidity injection, either through additional equity or via debt. For smaller unlisted firms it is usually not feasible to raise the raise equity, therefore they are usually left with the debt option and rely on credits from banks (Pagano and Zechner,

2022). Pagano and Zechner (2022) analyzed the effects of covid 19 on European companies' financial performance and found evidence suggesting differences in the effects between large firms and small and medium sized enterprises. By comparing the years 2019 and 2020 the authors found that smaller companies tend to increase their ratio of total debt to total assets (debt-ratio) whereas, large companies also increase their leverage, but significantly less. Regarding liquidity, their findings suggest that small and medium sized enterprises increased their cash-to-total-assets-ratio more than large companies. Small companies did so even more than medium sized ones. However, the authors could only speculate on the reason behind this observation. Plausible reasons were precautionary cash hoarding and greater risk aversion. Additionally, Pagano and Zechner raise the theory that smaller companies were able to raise cash more easily due to the claim, that loan guarantee programs favored small firms. However, there is no indication that the analyzed sample of small and medium sized enterprises was representative of any specific industry, nor of aid recipients in general (OCED, 2021). The disproportionate effect on SMEs is related to the overrepresentation of SMEs in industries that are particularly affected by the pandemic shock and the tendency to have smaller cash reserves than larger companies

Credits from banks, if obtainable, increase the firm's leverage and could make the firm vulnerable to new liquidity shortfalls. And additional leverage only prevents insolvency if there is a prospect that future cash flows will enable a firm to service the additional debt. Regarding solvency, increased leverage means a weaker equity ratio. An early Survey study from September 2020 analyzed the implications of the pandemic crisis on the equity of German companies and reported that for most companies the equity ratio did not change, however a strong sectoral heterogeneity with travel and gastronomy having a reduction in the equity ratio between 1.8 % and 1.5 % (Peichl et al., 2021). In Spain a survey looked at the indebtedness as well as the cash ratio of enterprises and reported findings that support the heterogeneity of the covid 19 shock across firms and, that the impact was larger for small, young and less productive firms located in urban areas (Fernández-Cerezo et al., 2021). Further support for the heterogeneity of the impact of the COVID-19 crisis on firms' sales and costs came from Belgium (Dhyne and Duprez, 2021). Regarding the indebtedness of firms, (Julin, Otte, and Kuchler, 2021) report for Denmark that credit growth was modest during the pandemic and that firms even find managed to reduce.

The effects of increased debt can be versatile in many aspects and depend on various factors. A simulation on 14 relatively well-covered European countries estimated that an increase in the financial debt of companies has on average a negative impact on the growth of investment after the crisis, indicating negative long-term effects of increased leverage (Demmou et al., 2021a).

2.2 Government support effects

The magnitude of policy responses has already provoked many researchers to look into the effects and effectiveness of various support measures. The difficult data situation has led scientists to explore different routes. Early attempts overcame the lack of data by conducting simulation studies. (Ebeke et al., 2021) estimate that in Europe the share of illiquid firms would have tripled from pre-crisis levels in the absence of policy measures. A modeling approach by (Puhr and Schneider, 2021) indicates that supporting measures in Austria helped to reduce insolvencies by around one-third. For European companies, a simulation by (Demmou et al., 2021b) suggests that the combination of different measures helped to reduce the share of illiquid companies significantly with relief for wage bills being the most effective tool.

A model by (Chang, Gan, and Mohsin, 2022) suggests that deferring taxes is the single best option for income cuts of 25 %, but a combination of loan and equity based aid is the best option when revenue drops are larger than 50 %. The modeling by (Parlapiano et al., 2020) supports the effectiveness of Italian support measures in reducing illiquidity, but also reports that loan based aid increased the indebtedness measured by a debt-to-asset like ratio of 1.2 %.

With a conceptual approach (Bischof et al., 2021) assessed the regulatory design of grants in Germany and argue for heterogenous effects for different industries based on their cost structure. Their justification is based on transmission factors which are referring to the relationship between the average decrease in revenue and the average decrease in profit of an industry. The factor can be crucial for the effect of aid schemes that are compensating costs proportionately because it has implications on the relative compensation of profits (Bischof et al., 2021). According to the numbers provided in the paper, Food and beverage service activities are industries with a higher

transmission than Travel agency and tour operator activities, as well as creative, arts and entertainment activities. Even lower transmission is reported for the industry of sports activities and amusement and recreation activities.

Other assessments were based on survey data from various countries in many ways. Indications for positive effects aid for micro microenterprises as well as self-employed are reported by (Kochaniak, Ulman, and Zajkowski, 2023; Bertschek et al., 2022).

A firm-level assessment was conducted by (Bellucci et al., 2022) suggesting that remedy measures in Italy have almost halved the percentage of illiquid SMEs at the end of 2020. In Slovakia, government wage subsidies reduced the probability of illiquidity for recipients (Lalinsky and Pál, 2021). Similar findings were also reported for Euro area firms by (De Santis, Ferrando, and Gabbani, 2021) and worldwide by (Igan, Mirzaei, and Moore, 2023).

(Harasztosi et al., 2022) find evidence that companies that got support expanded their balance sheet more than unsupported firms. In case of an expansion through debt, part of the change could be explained by the loan-based aid, but not in the case of equity, although the authors report that policy support raised the probability of an increase in the equity base (Harasztosi et al., 2022).

(Stien and Risan, 2022) analyzed the effect of tax deferrals in Norway and reports evidence for a significant decrease in the risk of bankruptcy. The measures taken by the Belgian authorities to mitigate the impact of the pandemic on companies' earnings have been effective in averting serious solvency issues (Piette and Tielens, 2022). (Costa, 2021) used a difference-in-differences method to assess different types of support in Portugal. The reported average treatment effects for debt-based that aid measures suggest a considerable contribution to firms' liquidity.

(Marek and Gärtner, 2022) investigated the effects of a grant based support scheme (November-December aid) in Germany based on survey data for around 2,300 firms. Their study suggests that those who were granted aid have a 5 - 6% lower probability of having a liquidity shortfall within one month. Their coefficients for longer periods are indicating a decrease in the aid effect on liquidity. Although most estimates are statistically insignificant, the results can mean that liquidity injection can only be measured in the very short run and is vanishing over the following month (Marek and Gärtner, 2022) also find strong evidence that firms consider bank loans to be a substitute for the provision of transfers.

(Dörr, Licht, and Murmann, 2022) have a critical view and argue that liquidity support measures in combination with the suspensions of the duty to file for insolvency have caused an insolvency gap, especially for smaller firms. Their understanding of an insolvency gap refers to keeping firms alive that were already struggling before the pandemic.

Chapter 3

Data Sources

3.1 Data on Government support

This thesis uses data from the European state aid transparency database (EU COM, 2023). The database contains information about individual award data like beneficiary name, amount, Date of Granting, and the purpose of the state aid (EU COM, 2023).

The legal base for the transparency requirement aid payments is Temporary Framework for State aid, however payments under 100.000 EUR (10.000 EUR for an agricultural firm) are exempted from the transparency requirement, insofar as the data base is not comprehensive. Nevertheless, as of spring 2023 for Germany 135.478 cases of aid related to the COVID-19 pandemic were disclosed under the objective "Remedy for a serious disturbance in the economy".

Most direct grants were granted and paid on a provisional basis and are still subject to a final determination of the granted amount. For the research, this does not pose an issue, since the effects of payments will be observable regardless of whether the amount of aid got adjusted in a later period. Additionally, in the case of bigger companies the aid was usually calculated on a group level but awarded and paid in full to just one company of the group.

3.2 Company level financial information

In Germany, corporations are legally required to disclose their annual financial statements in the Federal Gazette. Although the discloser of financial information is legally required for corporations, and there are various exemptions for example for companies that are consolidated into other companies' balance sheets, and also for non-compliant companies. The requirement on the disclosed financial information is depending on the size of the

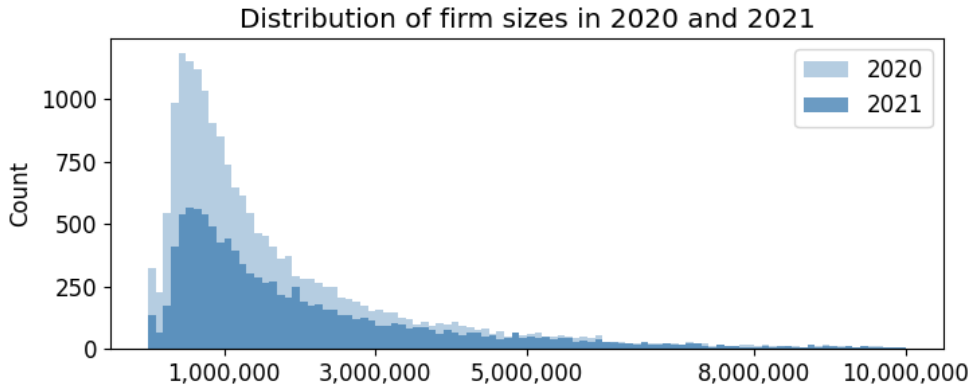

FIGURE 3.1: Histogram shows the distribution of total assets as a proxy for the size of the firms in the dataset. The X-axis is cut off at 10 Mio. Euros.

company. Bigger companies above certain thresholds additionally need to disclose their profit and loss statements and management reports additionally. However, all companies that are subject to regulation must disclose at least their balance sheet. To not exclude SMEs systematically, due to missing profit and loss statements, the data collection process is limited to balance sheet information.

The main constraint in processing the financial information from the Federal Gazette is the vastly unstandardized formatting of balance sheets causing limited readability in the data parsing step. By scraping and parsing the financial information for beneficiaries of the pandemic government support in total balance sheets of 23.505 companies for at least one year in the period 2018 - 2022 was obtained. Figure 3.1 shows that SMEs are represented in the dataset and that the distribution between 2020 and 2021 is comparable.

It is necessary to mention, that in cases of two companies of the same name the matching is prone to mismatches, and information for registry numbers of firms for validation was not consistently available in the database on state aid.

3.3 Insolvency information

To further understand how effective the aid measures were in preventing insolvencies, data on insolvencies in Germany was obtained from the insolvencies notification platform and matched with the beneficiaries of government support on the state aid transparency database. The data from the insolvencies notification platform data was used for the matching ranges from 2020 to

March 2023. Like with the matching of financial information with the beneficiaries, matching was also prone to mismatches in the case of two companies of the same name.

Chapter 4

Methods

4.1 Balance Sheet Ratios

To evaluate the financial position and performance of firms in a comparable way across the data set a selection of balance sheet ratios were chosen. Ratios allow a consistent view of the companies despite their different sizes. Even though balance sheets only offer a reporting date view of the firm's financial information and can't reflect events or extreme situations during a fiscal year, they provide a comparable view of companies that is standardized by accounting standards. The selection of ratios was made to get a picture of the liquidity and solvency the of firms. The ratios are calculated for each beneficiary of government support for each available year between 2018 and 2021. Calculations are shown in Table 4.1.

4.1.1 Liquidity Ratios

Liquidity ratios are chosen to measure a firm's financial position to meet its obligations in the short run. As outlined in Chapter 1, the pandemic shock had a significant effect on companies' liquidity and was a key consideration for the EU to loosen state aid regulation and enable large scale support measures (EU COM, 2020). The first and most representative liquidity ratio is the cash ratio, comparing the most liquid asset, cash holdings, to the total assets of a firm. Cash is the starting buffer against running costs in a crisis shock. Although usually the current liabilities are used instead of the total assets, with the available data total assets serve as a more robust denominator that has been utilized in similar research (Fernández-Cerezo et al., 2021; Costa, 2021; Igan, Mirzaei, and Moore, 2023). The quick and the current ratio provide a more conservative view of a firm's liquidity by including assets that are still considered relatively liquid against the current (short-term) liabilities. However, the key component, is short term debt, is not disclosed

TABLE 4.1: The calculation of Balance Sheet Ratios.

Category	Ratio	Calculation
Liquidity	Cash Ratio	$\frac{Cash}{TotalAssets}$
	Quick Ratio	$\frac{CurrentAssets-Inventory}{CurrentLiabilities}$
	Current Ratio	$\frac{CurrentAssets}{CurrentLiabilities}$
Liability	Debt-to-Equity Ratio	$\frac{Debt}{Equity}$
	Equity Ratio	$\frac{Equity}{TotalAssets}$
	Debt-to-Assets Ratio	$\frac{Debt}{TotalAssets}$

consistently in balance sheets since accounting standards allow alternative discloser in the balance sheet appendix. For practicability, such a case the calculation had to use the total liabilities, which reduced the informative value in comparisons across firms, but still allows for comparisons on a firm level between different years.

4.1.2 Solvency Ratios

The other factor of interest is the indebtedness of the firm in the context of the pandemic and the remedial measures. The indebtedness, or also leverage, of a firm has implications that are rather relevant in the long-term, since debt payments are long term obligations that need to be serviced by cash flows. High levels of debt can challenge a company and can reduce profits. The debt-to-asset and the equity ratio compare the respective capital to the total assets and are behaving in opposite directions. The debt-to-equity ratio gives a magnified picture of the companies leverage compared to the debt-to-asset ratio. For the simplification purposes, negative ratios were omitted since result either from errors in the data parsing process or from exceptional cases like loss transfer agreements with parent companies.

4.2 Difference-in-Differences

With the obtained firm-level data the first analysis tries to (1) measure the causal treatment effect of government support during the COVID-19 pandemic and (2) explore how the effects between aid instruments on the ratios from section 4.1 differ. To estimate the causal effect of aid, the fact that aid

measures were granted consecutively over the years 2020-2023 is used for a natural experiment with a standard difference-in-differences method to estimate the average treatment effect on the treated (ATT). In this setting the ATT can be described as the average causal effect of an aid instrument on the balance sheet ratio of companies that received support. In mathematical terms can be described as follows:

$$ATT = E[Y_{ratio,1i}|aid = 1] - E[Y_{ratio,0i}|aid = 1] \tag{4.1}$$

The first term describes the expected balance sheet ratio amongst the companies that got aid. The second part describes the unobservable expected ratios of the very same group of companies if they won't have received any aid. In the quasi-experimental setup, the periods 2019 and 2020 will be compared, and companies that received support in 2020 serve as treated group, while companies that did not receive support in 2020, but later in 2021 or 2022 serve as control group. The classification in treated and untreated is based on the cut-off dates of the firm's balance sheets and the date of granting the support. The setting is also performed for the periods 2020 and 2021, where the companies in the control group only received aid in 2022. For the estimation of the difference-in-difference a regression with the following linear model is used:

$$ratio_{ft} = \beta_0 + \beta_1 aid_f + \beta_2 post_t + \beta_3 aid * post_{ft} + \varepsilon_{ft} \tag{4.2}$$

Where the dependent variable is the ratio for firm (f) in period (t). The coefficients on the right side of the equation are the dummy variables aid, post, their interaction term $aid * post$ and the unobserved "error" term ε. The first independent variable *aid* equals 0 when firm (f) did not receive support until after the experiment period and is in the control group. The variable *aid* equals 1 when the firm did receive support and is considered treated in the experiment period. The second independent variable *post* indicates pre- and post-shock periods resembled by 0 and 1. The third and main variable for the difference-in-difference method is the interaction term $aid * post$ which will only be 1 for a treated firm ($f = 1$) in the treatment period ($t = 1$). The coefficient of the interaction describes the change in the dependent variable due to the treatment as illustrated in Table 4.1. It can be seen that by inserting the values of aid and post the coefficient β_3 of the interaction of *aid* and *post* is the estimated difference-in-difference.

The central assumption for the difference-in-difference methodology is

TABLE 4.2: Difference-in-difference with regression

	After($post = 1$)	Before ($post = 0$)	After - Before
Treated ($aid = 1$)	$\beta_0 + \beta_1 + \beta_2 + \beta_3$	$\beta_0 + \beta_1$	$\beta_2 + \beta_3$
Control ($aid = 0$)	$\beta_0 + \beta_2$	β_0	β_2
Treated - Control	$\beta_1 + \beta_3$	β_1	β_3

that the control and the treatment group are comparable and would behave parallel in over the observed periods, if there would not be a treatment. The proposed setup is based on the assumption that companies who received aid at any point during the COVID-19 pandemic were sufficiently affected by the shock to be eligible for support and subsequently confirm the parallel trends assumption.

The methodology will be used to measure the effects of grants and loans separately for all ratios in 2020 as well as 2021. Due to the outliers in the ratios the upper and lower fifth percentile is omitted.

4.3 Causal Curve

Next, the effect of support during the COVID-19 pandemic will be further analyzed by considering the amount of support as a continuous variable, instead of a binary variable like in the difference-in-differences approach. Estimating the effect of a continuous treatment can be evaluated through generalized propensity scores and described by a dose-response function showing the causal effect at each dose of treatment.

The groundwork was done by (Hirano and Imbens, 2004), by exploring the propensity scores methods for continuous treatments.

Generally, propensity scores refer to the probability of a unit being exposed to a treatment (binary or continuous) given pre-exposure covariates (Rosenbaum and Rubin, 1983).

The initial approach by Hirano and Imbens estimates the generalized propensity score (GPS) as the probability density function of the treatment conditioned on pre-exposure covariates, before combining the GPS with the treatment in a regression model to estimate a response to a treatment dose (Hirano and Imbens, 2004).

Compared to a traditional regression method, the GPS approach allows adjustment for possible confounders and the removal of bias in the estimation of the treatment effect, which can be crucial in observational studies (Wu et al., 2021; Moodie and Stephens, 2012).

Efforts by (Moodie and Stephens, 2012) and (Galagate, 2016) expanded on the concept of GPS' from Hirano and Imbens and proposed alternative estimators for dose-response functions.

This thesis uses the concept of transforming continuous treatments into probability density functions to approximate a dose-response for the government support. The estimation for both the generalized propensity scores and the dose-response function follows an implementation from (Kobrosly, 2020). The approach consists of three steps. First, the probability of the treatment T, referring to the amount of aid, is modeled by conditioning it on a set of covariates X using a normal generalized linear model (GLM):

$$T_i|X_I \sim \mathcal{N}(X_i^T\beta, \sigma^2) \tag{4.3}$$

The probability density function of the fitted values and the actual treatment is then estimated to get a GPS for each firm. To prevent possible confounding the variable shown in 4.3 were used as covariates. In the second step, the outcome Y, representing the observed change in liquidity for each firm, is fitted on the observed treatment T and the GPS from the first step using a linear generalized additive model.

In the last step the model is used to predict the treatment response in liquidity at a multiple levels to of the aid payments to visualize the causal effect as a causal dose response curve (CDRC).

The needed assumptions for the methods are that government support for one company will not affect the outcome for another company (Stable Unit Treatment Value Assumption). The only scenario where this could be violated is when two affiliated companies in the data set both received support but pool the money in one company. Second, the positivity assumption can also be confirmed since every company has some possibility of receiving support and the support is positive. The third assumption of unconfoundedness is most critical for observational studies. It has to be assumed that any relationship between potential outcomes in liquidity and the received support can be fully explained by the included covariates. By including the in Table 4.3 presented covariates the issue of potential unobserved confounders was attempted to reduce best possible with the available data. How, it is likely

TABLE 4.3: Covariates for GPS and dose-response function

Covariates	Explanation
aid_loan_2020	Values of loans that the company received in 2020
aid_loan_2021	Values of loans that the company received in 2021
aid_loan_2020	Values of grants that the company received in 2020
assets_2020	Total assets of the company in 2020 as a proxy for company size
debt_to_asset ratio 2020	Ratio to reflect the indebtedness of a company prior the aid is granted
days_grant_2021	A variable that indicates the days between the granting and the cutoff date of the financial report

that there are additional unmeasured confounders that weren't observed introduced bias to the results.

Chapter 5

Results

5.1 Data insights on beneficiaries

5.1.1 Liquidity

In Figure 5.1 the calculated ratios for all companies of the dataset are shown with boxplots for the years 2018-202. With the median, shown as the middle line in the box, the first and the third quartile, boxplots allow a simple comparison between the years that is not sensitive for outliers. The three observed liquidity ratios show an increase in liquidity in 2020 and 2021 compared to the pre-pandemic years, indicating that companies were holding relatively more cash at the year-end since the pandemic. Overall, the observations are in line with a study conducted by the German Federal Bank that also reported an increase in the average cash ratio for the whole population of German companies in 2020 as well as in 2021 (Deutsche Bundesbank, 2022). For example, for SME corporations the study reported a change in the cash ratio from 0.104 (2019) to 0.110 (2020). For the current ratio and quick ratio, the same trend was reported. Further support for an increase in the quick ratio comes from another study by (Bley et al., 2022). Although the exact ratios are varying between studies, there is strong support for the general trend of increasing liquidity in 2020 and 2021. What also can be seen in Figure 5.1 is that the whiskers of the boxplots are longer in the pandemic years, showing the heterogeneity of liquidity levels for firms. Considering that the ratios only reflect the status of the cutoff date, this can also be an indicator that the liquidity levels of firms are more volatile than before the pandemic which could be caused by forecasting difficulties in the liquidity planning during the pandemic.

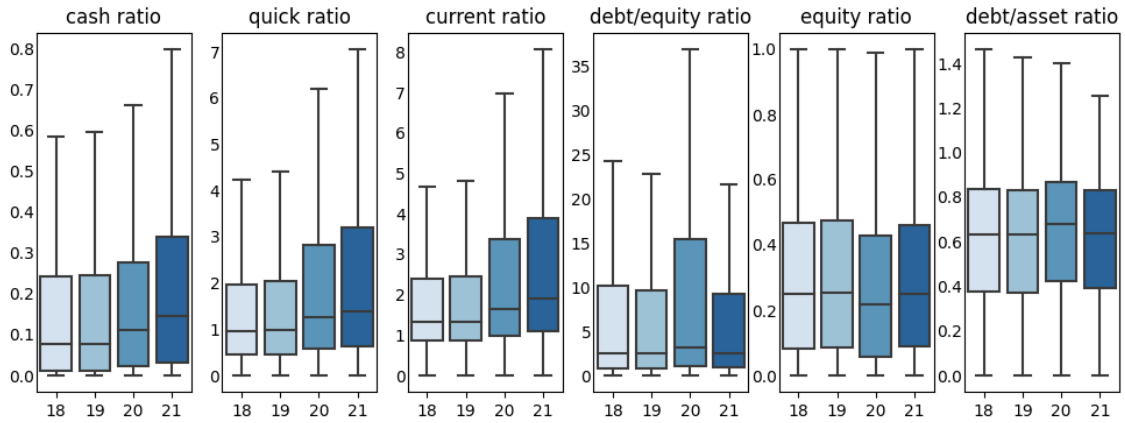

FIGURE 5.1: Boxplots with balance sheet ratios from the obtained dataset. Extreme outliers above the maximum values are not shown.

5.1.2 Solvency

Solvency ratios are showing a less clear trend after the COVID-19 pandemic. Although minimal, the opposite trends in the equity ratio and debt-to-asset ratio are as expected. The only visible change happened in 2020, while in 2021 the ratios are very similar to 2018 and 2019. The change in the debt-to-asset ratio is amplified in the debt-to-equity ratio, as expected. Survey Data from the KFW found an Equity Ratio of 0.318 in 2019, a decrease to 0.301 in 2020, and a recovery to 0.314 in 2021 (KfW, 2022). For very small companies with less than 10 employees, the drop in 2020 was stronger, and the recovery in 2021 was above pre-pandemic levels. On the other hand, the survey reported that larger companies did not have a recovery after the first crisis year and decreased their Equity Ratio in 2021 on average further. This could indicate that the recovery of the indebtedness of beneficiaries in 2021 might have been driven by smaller companies. Similar observations were reported by the German Federal Bank were the debt-to-asset ratio for SME corporations decreased in 2020 (Deutsche Bundesbank, 2022).

5.1.3 Insolvencies of beneficiaries

In total 953 insolvent firms were identified representing a share of 0.92 % of all beneficiaries of pandemic aid from the transparency database, as shown in Table 5.1. A further breakdown reveals that the share of SMEs is significantly lower than their larger counterparts. Since the transparency database only provides very few beneficiaries with aid payments below 100.000 EUR,

TABLE 5.1: Share of insolvent aid beneficiaries by size

size	aid beneficiaries	insolvent	share
SMEs	78077	526	0.67%
Large companies	25259	427	1.69%
Total	103336	953	0.92%

TABLE 5.2: Share of insolvent aid beneficiaries by industry

industry	beneficiaries	insolvent	share
Food and beverage service activities	15173	88	0.58%
Retail trade, except of motor vehicles a	8810	84	0.95%
Specialised construction activities	4103	68	1.66%
Wholesale trade, except of motor vehicle	5396	56	1.04%
Manufacture of fabricated metal products	3105	40	1.29%
Office administrative, office support an	3040	28	0.92%
Sports activities and amusement and recr	5232	27	0.52%
Accommodation	9885	24	0.24%
Wholesale and retail trade and repair of	3525	17	0.48%

Notes: The table shows industries with more than 3000 beneficiaries and is sorted by insolvencies. The industry names are truncated after 40 characters.

smaller companies with aid below the threshold are not well represented. Therefore, the numbers only give an indication.

In the next step the industries of insolvent beneficiaries were analyzed. The results for the most represented industries are presented in Table 5.2. A more comprehensive table with more industries is in Appendix B. The findings show that food and beverage service activities are the industry with the most beneficiaries, but only have a share of 0.58 % of insolvencies that well below the average.

Similarly, the accommodation sector is highly represented. With only 24 insolvencies out of 9.885 recipients, it has the lowest share amongst the most represented industries. On the higher end are specialized construction activities with a share of 1.66 %. The closely related construction building sector has an even higher share with 2.97 %, but is less represented and therefore only shown in the appendix. Partially, even higher shares are present in the data, but only in underrepresented industries.

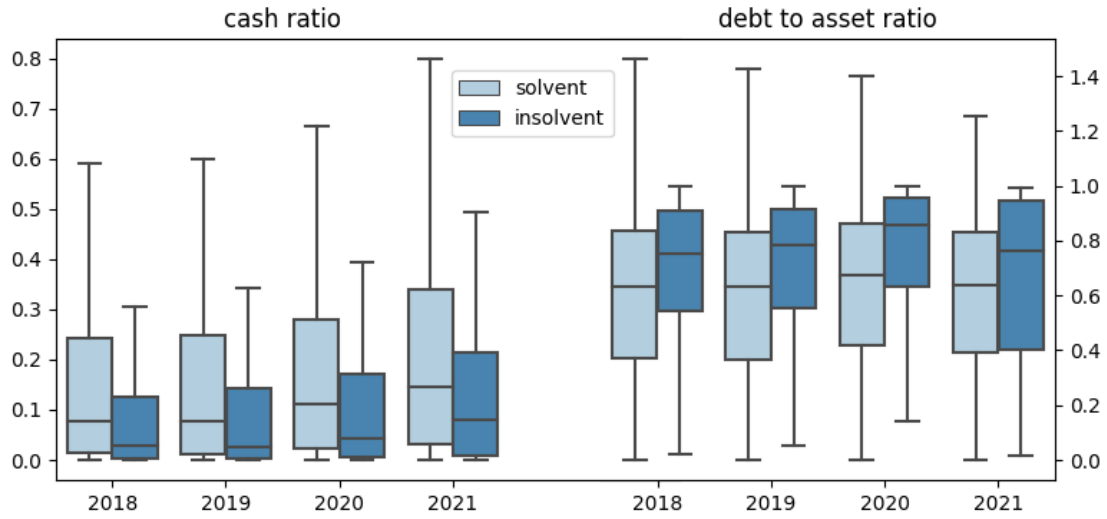

FIGURE 5.2: Boxplot with balance sheet ratios from the obtained dataset.

5.1.4 Ratios of insolvencies

Next, the ratios of insolvent beneficiaries are analyzed and compared to the other beneficiaries. For the comparison, the cash ratio and the debt-to-asset ratio are chosen to analyze the liquidity and solvency. Figure 5.2 shows the already for section 5.1 used boxplot, but grouped into a solvent (light blue) and insolvent by the spring of 2023 (darker blue). For the liquidity ratio, a clear discrepancy can be observed throughout all periods. The group of companies that later got insolvent has already before 2020 significantly less liquidity than the other group. However, in 2020 and 2021 their cash ratio is also increasing, like the solvent group. The debt-to-asset ratio comparison also shows a clear gap between both groups. The companies which are later becoming insolvent have higher leverage before and after the start of the pandemic.

5.2 The effect of government support

5.2.1 The average effect on firm liquidity

The interaction terms from the difference-in-differences regressions are shown in Table 5.3. The coefficients for the aid and post coefficients are reported in Appendix A. In the first-row cash ratio coefficients are reported for grants

and loans. In the 2020 column the effect for grants is the only cash ratio coefficient that is not statistically significant.

In 2021 the coefficient for grants on the cash ratio was estimated to be 7.68 % indicating a strong causal effect. The average treatment effect for firms that got aid through loans is positive in 2020 and 2021, but less strong than grants. Also, the effect in 2021 is less strong compared to 2021.

The quick ratio and the current ratio only have statistical significance for loans. At a significance level of 1 %, only the quick ratio and the current ratio coefficient for 2020 are significant. The treatment effects with 10.85 % and 12.71 % are even stronger than for the cash ratio. The effects for the current ratio are even larger, reflecting the proportionality between the ratios. Overall, the results show strong effects of loans on the observed liquidity ratios. For grants an even stronger effect was observed in 2021, but only for the cash ratio, not for the more conservative ratios. However, this could be caused by the alternative calculation of the quick and current ratio that was used for part of the companies.

In summary both aid measures have a significant effect on the cash ratio indicating a liquidity boost. The measured increase in liquidity through loans indicates that they were not used for refinancing existing debt, but served as liquidity injection as intended by the policy makers.

5.2.2 The average effect on solvency of firms

In the row for the debt-to-equity ratio strongly positive coefficients were observed for loans in 2020 and 2021. Since the debt-to-equity ratio reflects a firm's leverage it is plausible that loans have a causal effect on debt. Regarding the equity ratio in the following row, a negative effect of loans was estimated for 2020 and 2021. For grants, which aren't affecting a firm's debt, no statistically significant effect was observable and thus indicating that grants didn't support the equity of firms. Further support for the increase in leverage through loans comes from the debt-to-asset ratio coefficients. The effects for loans are strong in 2020 and 2021 with 7.15 % and 5.26 %. For grants, the causal effect is 4,12 % in 2020 and reversing in 2021 to - 3.02 %. The positive effect in 2020 is in line with the missing effect on the equity ratio. The negative coefficient in 2021 on the other hand, indicates that grants helped firms to reduce leverage by slightly.

Consequently, the increase in leverage from loans is measurable as expected. However, the estimates does not support the expectation that grants

TABLE 5.3: Government aid impact on ratios

	year	2020		2021	
	instrument				
cash ratio	**grant**	-0.0089	(0.270)	0.0768***	(0.000)
	loan	0.0527***	(0.000)	0.0351***	(0.000)
quick ratio	**grant**	-0.0937	(0.221)	0.0913	(0.478)
	loan	0.1085***	(0.000)	0.0929	(0.252)
current ratio	**grant**	-0.0825	(0.330)	0.0476	(0.736)
	loan	0.1271***	(0.000)	0.1828*	(0.064)
debt to equity ratio	**grant**	0.2478*	(0.089)	-0.1592	(0.185)
	loan	0.7306***	(0.000)	0.5043**	(0.016)
equity ratio	**grant**	-0.0112	(0.371)	0.0108	(0.465)
	loan	-0.0486***	(0.000)	-0.037***	(0.004)
debt to assest ratio	**grant**	0.0412***	(0.006)	-0.0302*	(0.079)
	loan	0.0715***	(0.000)	0.0526***	(0.002)

Notes: Standard errors in parentheses, *** p<0.01, ** p<0.05, * p<0.1

protect the equity of firms. The positive effect of grants on the debt-to-asset ratio and the missing effect on the cash ratio in 2020 suggest that the grants were not sufficient to prevent liquidity shortfalls and therefore companies had to rely on debt from other sources for additional liquidity. The reversal of the effect on the debt-to-asset ratio and the effect on the cash ratio in 2021 suggest that grants only became effective in providing sufficient liquidity and reducing leverage in 2021. However, this could be related to the fact that only relatively few grants were provided in 2020.

5.2.3 Aid effect on companies that later become insolvent

The group of future insolvent companies was used for a another difference in differences experiment to estimate the treatment effect of aid on the subgroup. Results are shown in Table 5.4. Two coefficients with statistical significance were identified, both in 2020 and for loans. First, the treatment effect of aid was 0.0427 on the cash ratio. The effect is weaker than the 0.527 that was estimated on the complete data set. This can be understood that these companies absorbed the liquidity from loans quicker due to a greater need for liquidity. The other slightly significant coefficient indicates a positive effect on the debt-to-asset ratio of 0.0882 which is also higher than the overall effect observed from all companies. This shows that despite the loan based

TABLE 5.4: Government aid impact on ratios of insolvent beneficiaries

	year	2020		2021	
	instrument				
cash ratio	**grant**	-0.038	(0.605)	0.1469	(0.337)
	loan	0.0427**	(0.046)	-0.1302	(0.394)
quick ratio	**grant**	0.2732	(0.645)	0.4531	(0.598)
	loan	0.1349	(0.493)	0.2365	(0.728)
current ratio	**grant**	0.2117	(0.759)	0.3419	(0.666)
	loan	0.0444	(0.848)	-0.0784	(0.930)
debt to equity ratio	**grant**	-3.9105	(0.867)	1.0318	(0.588)
	loan	2.0475	(0.262)	6.8704	(0.663)
equity ratio	**grant**	0.0889	(0.588)	-0.1444	(0.405)
	loan	-0.0338	(0.381)	-0.2779	(0.467)
debt to assest ratio	**grant**	0.0797	(0.650)	-0.0763	(0.728)
	loan	0.0892*	(0.080)	0.1806	(0.580)

Notes: Standard errors in parentheses, *** p<0.01, ** p<0.05, * p<0.1

aid measures the later insolvent companies had a greater chance of indebtedness, than other companies. The higher debt-to-asset-ratio could also be an indication that these companies used debt from other sources. In any case, the, additional indebtedness increased the risk of insolvency.

5.3 Causal Curve

5.3.1 The relationship between liquidity and aid

The first implementation of the GPS methodology is used to compare the effects of grants in 2021 and loans in 2020 on firm liquidity in both relative (left) and absolute (right) terms. The respective visualizations are shown in Figure 5.3. The choice was based on the findings from the previous section and the data richness of these groups.

The relative illustrations show the modeled relation between the observed change in the cash ratio in dependence on the relative amount of aid in regard to beneficiaries' total assets. While the relative illustrations show the observed change in cash holdings and the aid amount in absolute terms. All illustrations use 95 % confidence bands.

Moreover, axis ranges are cut to allow for comparison within the shared ranges in each figure. The full axis ranges significantly different between groups, depending underlying on in the data.

What can be seen is that all curves show a clear upward trend till at least the middle of the observed ranges. Outstanding is the flattening curve in the bottom left in the second half of the range, while the others continue the upward trend. However, the findings could be related to the loan program "KfW-Sonderprogramm" which was bound to pre-pandemic revenue numbers in combination with fixed caps for the loan volumes. A diminishing effect could therefore appear for larger companies with loans that are capped by fixed thresholds. Since revenue can be considered as an alternative proxy for firm size, the diminishing effect could appear in the modeled relative relationship, but not in the absolute perspective.

With respect to the grants in 2021 parallel trends of the absolute and the relative views indicate a positive relationship between the level of aid and the liquidity increase which would be in line with the average causal effect of 7.7 % measured by the DiD approach.

The drop in the curve of the relative view on loans in 2020 could be represented by the smaller average effect liquidity (5.3 %) from the DiD approach Given the strong award trend in the absolute view, and the considerably positive coefficient still indicates a positive relationship.

5.3.2 The relationship of solvency and aid

Figure 5.4 shows the estimated dose response curves for loans and grants in 2021 with their effect on the indebtedness represented by the debt-to-asset ratio. The downward trend on the left side indicated a negative effect on the debt ratio like the DiD estimates (- 0.03 %) and an opposing trend in the respective relationship of loans, which confirms the initial assumption on the solvency effects.

Figure 5.5 show response curves for four selected industries that were used as example cases by (Bischof et al., 2021) for their assumption of heterogenous effects of grants between industries with different cost structures.

Of the four shows relations, the food and beverage sector has the highest transmission according to (Bischof et al., 2021), followed by the travel agency and tour operator sector and then the creative, arts, and entertainment industry. Last, with the lowest factor is the industry of sports activities, amusement, and recreation.

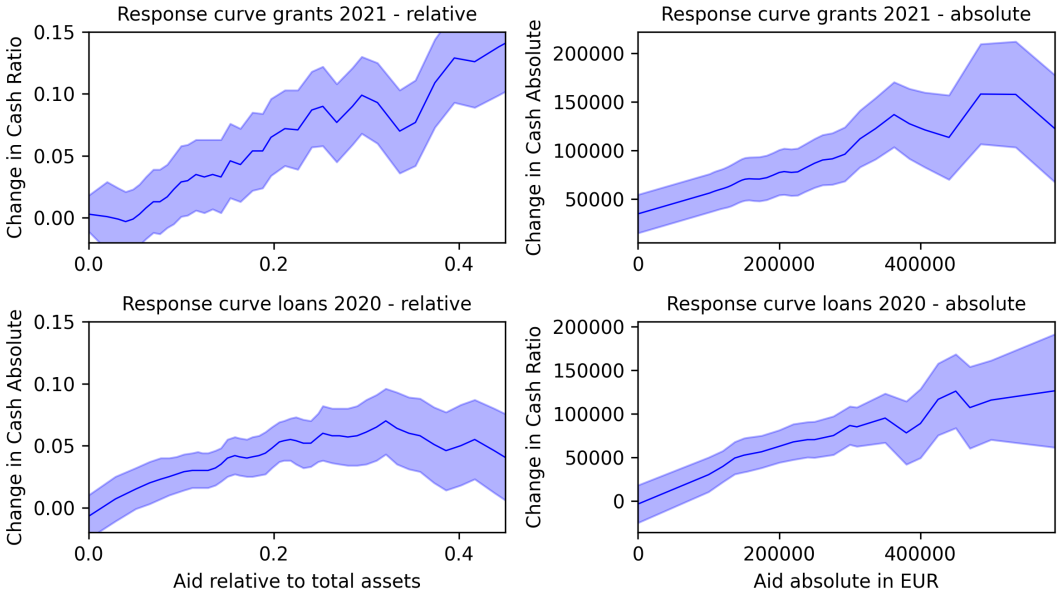

FIGURE 5.3: Estimated Dose Response Functions, for liquidity (cash) from grants 2021 (top) and loans 2020 (bottom) in relative (left) and absolte (right) terms with 95% Confidence Bands. For Binomial Distributed Data. The estimate of absolute variants used a lognormal GLM for the GPS estimation due to the different distribution of the variables.

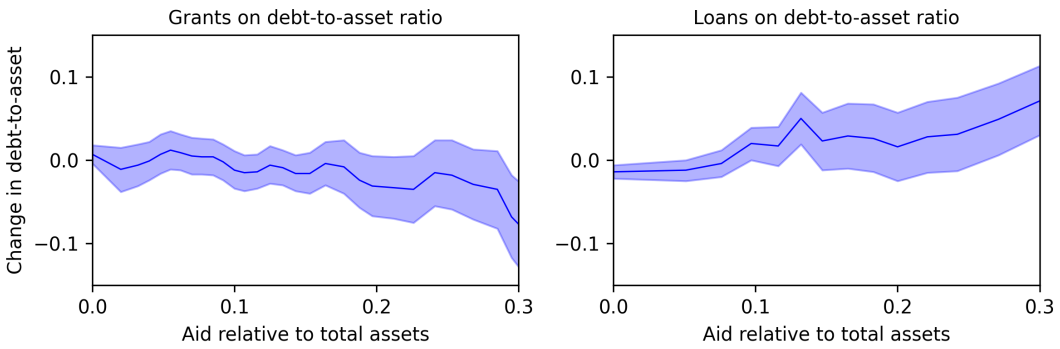

FIGURE 5.4: Estimated Dose Response Functions, for the debt-to-asset ratio from grants 2021 and loans 2021 in relative terms with 95% Confidence Bands

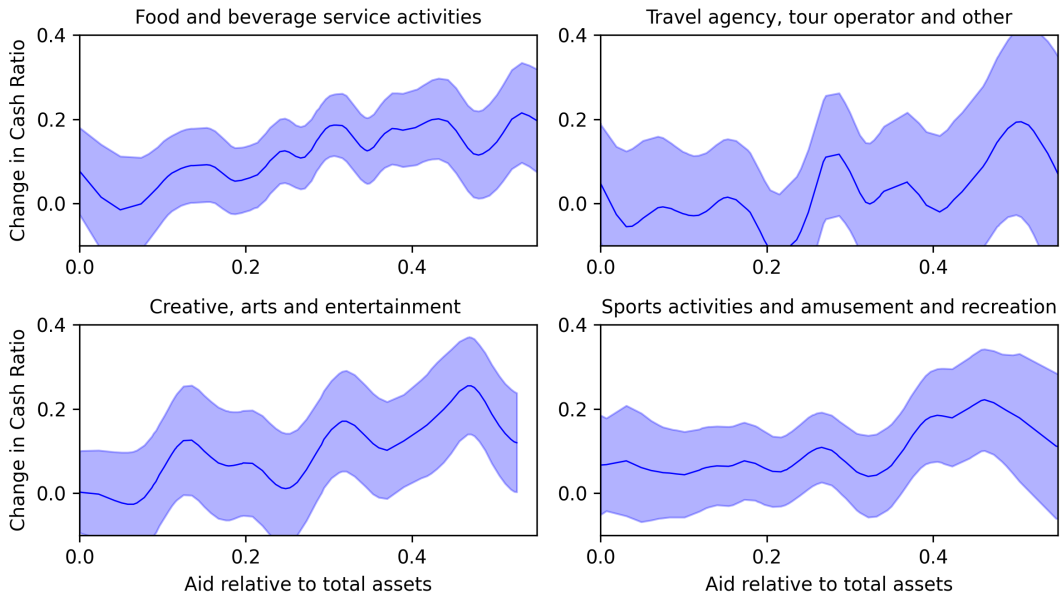

FIGURE 5.5: Estimated Dose Response Functions, for the cash ratio from grants 2021 in selected industries in relative terms with 95% Confidence Bands

With the estimated curves in Figure 5.5, the food and beverage sector has the most narrow confidence bands and the clearest upwards trends, while the least positive effect on the cash ratio can be interpreted for the travel agency and tour operator sector. However, the curves are highly sensitive to specifications and the wavy and wide confidence bands are indicating limited statistical significance and thus do not allow a reliable judgment confirming or denying a connection between the observed effects and the transmission factors from (Bischof et al., 2021).

Considering the additional industry curves from Figure **??** in Appendix 1, it can only be cautiously conclude that the general assumption of heterogeneous effects between industries cannot be rejected with the results obtained.

Chapter 6

Conclusion

6.1 Policy Implications

To mitigate the effects of the pandemic shock the German government responded with unprecedented fiscal efforts to provide liquidity to the economy and prevent business from failing. Policy responses of this magnitude are complex in many ways. The regulative aspect regarding European state aid regulations has been covered shortly in the introduction.

Finding the right balance between the effectiveness and efficiency of the policy response is a key challenge. On the one hand the support needs to be appropriate to provide sufficient relief since an economic collapse is not a considerable alternative. On the other hand, support needs also be targeted, helping with liquidity where needed and not creating excessive benefits. Under the pressure to keep the economy creating targeted aid measures that adequate aid for everyone is hardly obtainable.

For example, the right level of assistance is very crucial for highly vulnerable companies that were already struggling before the pandemic shock. Legitimate concerns about the side effects of generous support to this group of companies are present. The zombification, which refers to artificially keeping these companies alive and delaying inevitable default, as well as the distortion of competition are part of the concerns (Dörr, Licht, and Murmann, 2022). But also, considerations of fairness and the interpretation to whom the fairness should be interpreted. Policy makers were faced with difficult tradeoffs, especially given the possible chaining on insolvencies, which could have unmanageable consequences and possibly counteract the actual goals of the aid and hamper the effort that was already made.

A method that was utilized through grants schemes were provisional permits with expedited payouts for quick relief, but subject to repayment. Thus, allowing for a final determination of the granted amount at a later date.

In regard to the assessment of support measures no judgment on observed excessive liquidity is possible, since funds could still be due for repayment.

6.2 Conclusion

With the DiD regression effects from aid on the liquidity and solvency of companies were successfully measured. The results suggest that in 2020 loan-based measures supported companies by improving their liquidity by 5.3 %, while grant-based aid was insufficient as a liquidity injection since beneficiaries had no improvement in liquidity and relatively higher debt. However, in 2021 grants programs became effective in providing liquidity and preserving the equity of firms. In 2021 the liquidity increase of grant beneficiaries was 7.7 %, twice as high as the effect of grants in 2021.

Moreover, the insolvencies of aid beneficiaries were analyzed. Results suggest that they were already significantly weaker before the pandemic and that aid measures were less effective in supporting them compared to the overall population of beneficiaries. However, a sector view reveals that the industries that are most represented amongst beneficiaries gastronomy and accommodation show insolvency rates well below the average, suggesting that aid measures were successful in reducing the chance of insolvency in their presumed main target sectors.

Finally, the thesis provided a deeper understanding of the aid measures by exploiting the data granularity with a combination of generalized propensity scores and a generalized linear model (GLM). The visualizations were showing the relationship between changes in beneficiaries' liquidity as well as solvency at different aid levels. Overall, the visualizations are in line with the results from the DiD and don't show any concerning abnormalities. In greater detail, the visualizations reveal some heterogeneity amongst beneficiaries from different industries, which connects with the observed heterogeneity in insolvencies of different industries.

With the results obtained, limitations must also be recognized. In addition to limitations arising from the data sources and the inherent risk of mismatches during that matching process, the causal modeling for the DiD and the GPS involved strong assumptions such as the assumption of parallel trends and unconfoundedness that, if violated, can heavily bias the estimates.

In consideration of the overall results of the thesis and already existing contributions from other researchers the government support had a considerable role in carrying the economy through the pandemic. However, the future will require more in-depth assessments that fully reflect the repayments of excessive liquidity support and have a longer-term view on beneficiaries' insolvencies.

Appendix A

Appendix A

A.1 Complete coefficients for government aid impact on ratios

TABLE A.1: Complete coefficients for government aid impact on ratios

type	year	ratio	aid	post	aid*post
grant	2020	cash	0.0283*** (0.000)	-0.0023 (0.322)	-0.0089 (0.270)
		quick	0.2112*** (0.000)	0.321*** (0.000)	-0.0937 (0.221)
		current	0.0655 (0.274)	0.3501*** (0.000)	-0.0825 (0.330)
		debt to equity	-0.2703*** (0.009)	-0.0676 (0.111)	0.2478* (0.089)
		equity	0.0095 (0.268)	0.0124*** (0.001)	-0.0112 (0.371)
		debt to assest	-0.0347*** (0.001)	-0.0047 (0.295)	0.0412*** (0.006)
loan	2020	cash	-0.0406*** (0.000)	-0.0001 (0.966)	0.0527*** (0.000)
		quick	-0.2065*** (0.000)	0.2744*** (0.000)	0.1085*** (0.000)
		current	-0.1688*** (0.000)	0.3123*** (0.000)	0.1271*** (0.000)
		debt to equity	0.3667*** (0.000)	-0.055 (0.291)	0.7306*** (0.000)
		equity	-0.0058* (0.069)	0.0126*** (0.000)	-0.0486*** (0.000)
		debt to assest	0.0398*** (0.000)	-0.0013 (0.751)	0.0715*** (0.000)
grant	2021	cash	-0.0159** (0.033)	-0.0199** (0.037)	0.0768*** (0.000)
		quick	0.2879*** (0.002)	0.0147 (0.899)	0.0913 (0.478)
		current	0.2055** (0.039)	0.0768 (0.544)	0.0476 (0.736)
		debt to equity	-0.1569* (0.065)	0.0167 (0.877)	-0.1592 (0.185)
		equity	0.0123 (0.238)	0.0 (0.998)	0.0108 (0.465)
		debt to assest	-0.0231* (0.058)	0.0135 (0.385)	-0.0302* (0.079)
loan	2021	cash	-0.0319*** (0.000)	-0.0153** (0.027)	0.0351*** (0.000)
		quick	-0.2017*** (0.000)	0.0715 (0.269)	0.0929 (0.252)
		current	-0.2285*** (0.001)	0.1031 (0.188)	0.1828* (0.064)
		debt to equity	0.4226*** (0.005)	0.0749 (0.656)	0.5043** (0.016)
		equity	-0.0159* (0.082)	-0.0007 (0.947)	-0.037*** (0.004)
		debt to assest	0.0379*** (0.001)	0.0165 (0.219)	0.0526*** (0.002)

Notes: Standard errors in parentheses, *** p<0.01, ** p<0.05, * p<0.1

Appendix B

Appendix B

B.1 Full list of insolvent aid beneficiaries by industry

TABLE B.1: Share of insolvent aid beneficiaries by industry

industry	beneficiaries	insolvent	share
Employment activities	594	30	5.05%
Construction of buildings	1247	37	2.97%
Manufacture of basic metals	586	14	2.39%
Computer programming, consultancy and re	1481	35	2.36%
Manufacture of machinery and equipment n	2226	44	1.98%
Manufacture of computer, electronic and	728	13	1.79%
Specialised construction activities	4103	68	1.66%
Manufacture of rubber and plastic produc	664	10	1.51%
Printing and reproduction of recorded me	826	11	1.33%
Other manufacturing	689	9	1.31%
Architectural and engineering activities	929	12	1.29%
Manufacture of fabricated metal products	3105	40	1.29%
Land transport and transport via pipelin	2552	31	1.21%
Manufacture of food products	1537	17	1.11%
Gambling and betting activities	2061	22	1.07%
Wholesale trade, except of motor vehicle	5396	56	1.04%
Other personal service activities	2517	25	0.99%
Services to buildings and landscape acti	1018	10	0.98%
Retail trade, except of motor vehicles a	8810	84	0.95%
Warehousing and support activities for t	1620	15	0.93%
Office administrative, office support an	3040	28	0.92%
Advertising and market research	952	8	0.84%
Real estate activities	1413	11	0.78%
Manufacture of furniture	530	4	0.75%
Activities of head offices; management c	967	6	0.62%
Food and beverage service activities	15173	88	0.58%
Rental and leasing activities	868	5	0.58%
Sports activities and amusement and recr	5232	27	0.52%
Education	974	5	0.51%
Wholesale and retail trade and repair of	3525	17	0.48%
Creative, arts and entertainment activit	1485	6	0.40%
Human health activities	1417	5	0.35%
Travel agency, tour operator and other r	2756	8	0.29%
Motion picture, video and television pro	691	2	0.29%
Accommodation	9885	24	0.24%
Crop and animal production, hunting and	1803	4	0.22%
Legal and accounting activities	646	1	0.15%

Notes: Tables shows industries with more than 500 beneficiaries

Appendix C

Appendix C

C.1 Figure 5.3 with full Axis range

C.2 Figure 5.4 with full Axis range

C.3 Figure 5.5 with full Axis range

C.4 Dose curves from addtional industries

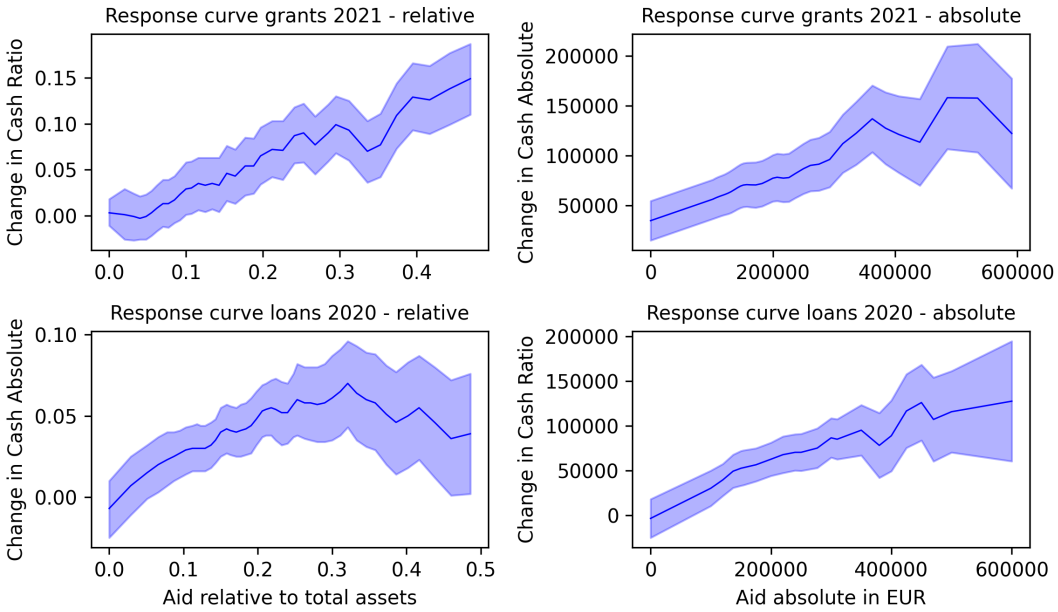

FIGURE C.1: Estimated Dose Response Functions, for liquidity (cash) from grants 2021 (top) and loans 2020 (bottom) in relative (left) and absolte (right) terms with 95% Confidence Bands. For Binomial Distributed Data. The estimate of absolute variants used a lognormal GLM for the GPS estimation due to the different distribution of the variables.

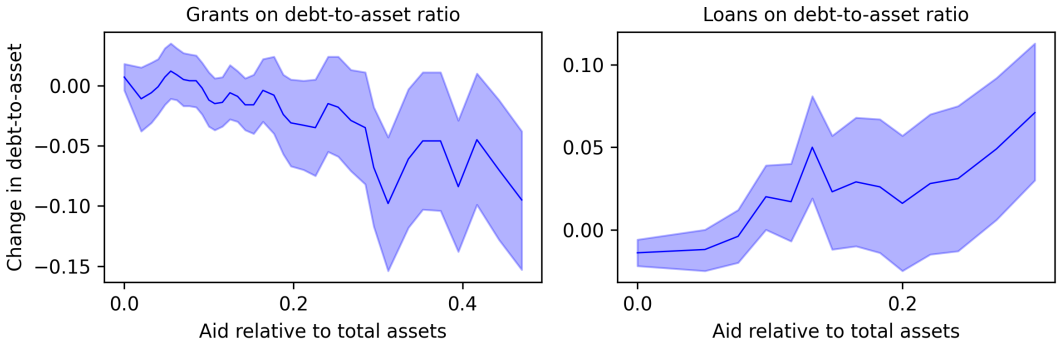

FIGURE C.2: Estimated Dose Response Functions, for the debt-to-asset ratio from grants 2021 and loans 2021 in relative terms with 95% Confidence Bands

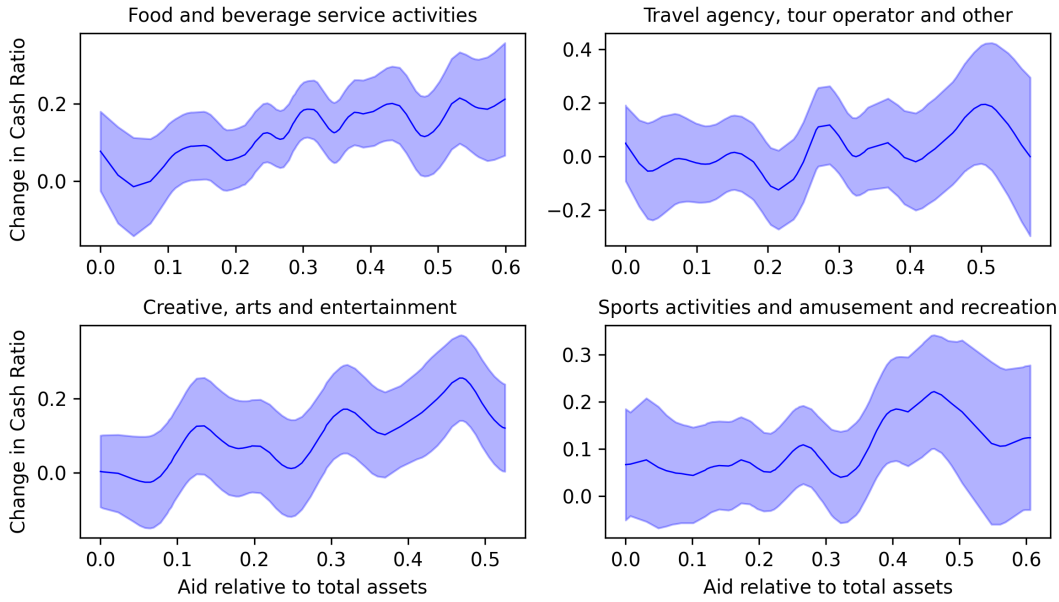

FIGURE C.3: Estimated Dose Response Functions, for the cash ratio from grants 2021 in selected industries in relative terms with 95% Confidence Bands

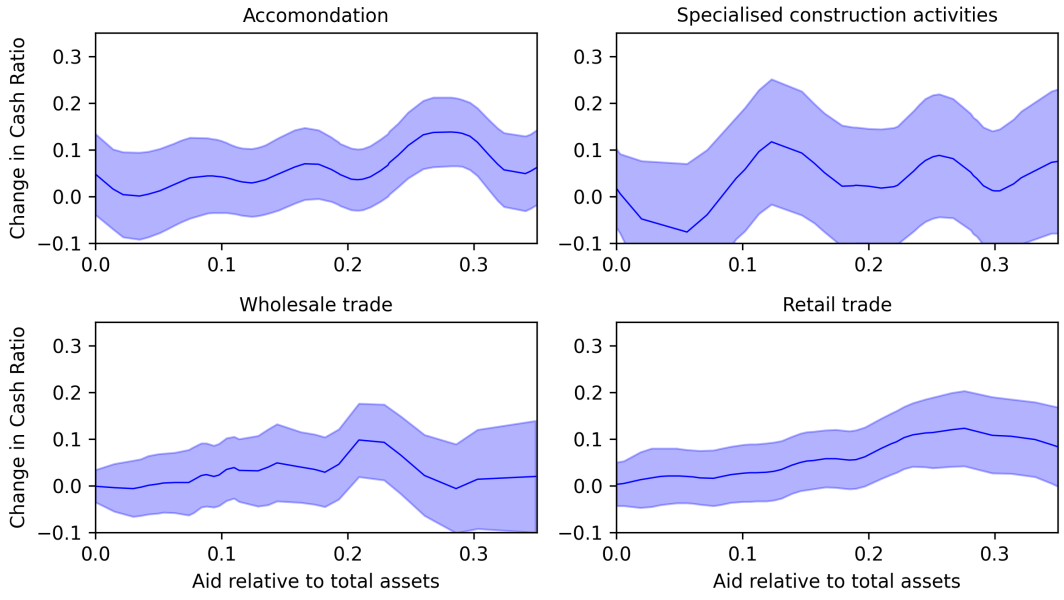

FIGURE C.4: Estimated Dose Response Functions, for the cash ratio from grants 2021 in selected industries in relative terms with 95% Confidence Bands

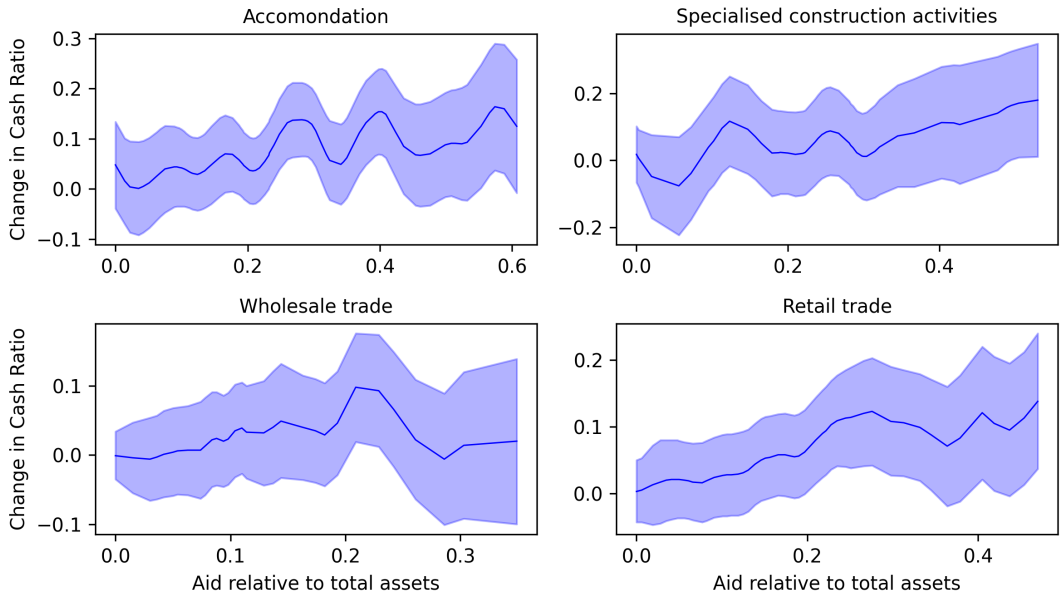

FIGURE C.5: Estimated Dose Response Functions, for the cash ratio from grants 2021 in selected industries in relative terms with 95% Confidence Bands

Bibliography

Bellucci, Chiara et al. (Sept. 2022). *The consequences of COVID-19 crisis on firms' liquidity needs*. en. Working Papers 15. Dipartimento delle Finanze.

Bertschek, Irene et al. (2022). "German Financial State Aid during COVID-19 Pandemic: Higher Impact among Digitalized Self-Employed". en. In.

Bischof, Jannis et al. (July 2021). "Die Bedeutung der Kostenstruktur für die Effektivität von Staatshilfen". de. In: *Wirtschaftsdienst* 101.7, pp. 536–543. ISSN: 0043-6275, 1613-978X. DOI: 10.1007/s10273-021-2962-x. URL: https://link.springer.com/10.1007/s10273-021-2962-x (visited on 04/11/2023).

Bley, Andreas et al. (2022). *Mittelstand im Mittelpunkt*. Tech. rep. BVR, DZ BANK. URL: https://www.bvr.de/p.nsf/0/31959EDD28C91416C1258916002CE183/%24FILE/Mittelstand%20im%20Mittelpunkt%20Herbst%202022-2.pdf (visited on 04/27/2023).

BMWK, Bundesministerium für Wirtschaft und Klimaschutz (June 2022). *Überblickspapier Corona-Hilfen Rückblick – Bilanz- Lessons Learned*. de. URL: https://www.bmwk.de/Redaktion/DE/Downloads/C-D/Corona/ueberblickspapier-corona-hilfen.html (visited on 04/24/2023).

Carboni, Oliviero A. (Apr. 2017). "The effect of public support on investment and R&D: An empirical evaluation on European manufacturing firms". en. In: *Technological Forecasting and Social Change* 117, pp. 282–295. ISSN: 0040-1625. DOI: 10.1016/j.techfore.2016.11.017. URL: https://www.sciencedirect.com/science/article/pii/S0040162516307016 (visited on 04/25/2023).

Chang, Lei, Xiaojun Gan, and Muhammad Mohsin (Dec. 2022). "Studying corporate liquidity and regulatory responses for economic recovery in COVID-19 crises". en. In: *Economic Analysis and Policy* 76, pp. 211–225. ISSN: 03135926. DOI: 10.1016/j.eap.2022.07.004. URL: https://linkinghub.elsevier.com/retrieve/pii/S0313592622001084 (visited on 04/16/2023).

Claici, Adina, Laurent Eymard, and Shahin Vallée (June 2022). *European Union: economists' perspective on state aid*. en. URL: https://globalcompetitionreview.com/review/the-european-middle-east-and-african-antitrust-

review/2023/article/european-union-economists-perspective-state-aid (visited on 04/08/2023).

Costa, Daniela Dias (2021). "State-Aids and Credit: Evidence from Portugal During Covid-19". en. Dissertation. Universidade do Porto (Portugal). URL: https://repositorio-aberto.up.pt/bitstream/10216/137491/2/513100.pdf (visited on 04/04/2023).

De Santis, Roberto A., Annalisa Ferrando, and Elena S. Gabbani (2021). "The impact of fiscal support measures on the liquidity needs of firms during the pandemic". en. In: *Economic Bulletin Boxes* 4. Publisher: European Central Bank. URL: https://ideas.repec.org//a/ecb/ecbbox/202100042.html (visited on 04/11/2023).

Demmou, Lilas et al. (2021a). *Insolvency and debt overhang following the COVID-19 outbreak: assessment of risks and policy responses*. en. OECD Economics Department Working Papers 1651. URL: https://www.oecd-ilibrary.org/economics/insolvency-and-debt-overhang-following-the-covid-19-outbreak-assessment-of-risks-and-policy-responses_747a8226-en (visited on 08/04/2023).

Demmou, Lilas et al. (2021b). *Liquidity shortfalls during the Covid-19 outbreak: assessment and policy responses*. en. OECD Economics Department Working Papers 1647. URL: https://www.oecd-ilibrary.org/economics/liquidity-shortfalls-during-the-covid-19-outbreak-assessment-and-policy-responses_581dba7f-en (visited on 08/04/2023).

Deutsche Bundesbank (2022). *Jahresabschlussstatistik (Hochgerechnete Angaben)*. de. Statistische Fachreihe. Deutsche Bundesbank. URL: https://www.bundesbank.de/resource/blob/827826/967001c31efc4ad77fed0abbe19f6ac0/mL/1-0-jahresabschlussstatistik-hochgerechnete-angaben-data.pdf.

Dhyne, E and C Duprez (2021). "Belgian firms and the COVID-19 crisis". en. In.

Dörr, Julian Oliver, Georg Licht, and Simona Murmann (Feb. 2022). "Small firms and the COVID-19 insolvency gap". en. In: *Small Business Economics* 58.2, pp. 887–917. ISSN: 1573-0913. DOI: 10.1007/s11187-021-00514-4. URL: https://doi.org/10.1007/s11187-021-00514-4 (visited on 04/11/2023).

Ebeke, Christian et al. (2021). *Corporate Liquidity and Solvency in Europe during COVID-19: The Role of Policies*. IMF Working Paper 2021/056. URL: https://www.imf.org/en/Publications/WP/Issues/2021/03/02/Corporate-

Liquidity-and-Solvency-in-Europe-during-COVID-19-The-Role-of-Policies-50133 (visited on 04/17/2023).

EU COM (2020). *Temporary Framework for State aid measures to support the economy in the current COVID-19 outbreak 2020/C 91 I/01*. en. URL: https://eur-lex.europa.eu/legal-content/EN/ALL/?uri=OJ:JOC_2020_091_I_0001 (visited on 04/24/2023).

— (2023). *State Aid Transparency*. URL: https://webgate.ec.europa.eu/competition/transparency/public?lang=en (visited on 04/25/2023).

Fernández-Cerezo, Alejandro et al. (May 2021). "Firm-level heterogeneity in the impact of the COVID-19 pandemic". en. In: *Documentos de Trabajo. N.º 2120*. ISSN: 1579-8666.

Galagate, Douglas (2016). "Causal inference with a continuous treatment and outcome: Alternative estimators for parametric dose-response functions with applications". en. PhD thesis.

Harasztosi, Péter et al. (Jan. 2022). "Firm-level policy support during the crisis: so far, so good?" en. In: *EIB Working Paper* 2022/01. URL: https://data.europa.eu/doi/10.2867/24308 (visited on 04/10/2023).

Hirano, Keisuke and Guido W. Imbens (2004). "The Propensity Score with Continuous Treatments". en. In: *Wiley Series in Probability and Statistics*. John Wiley & Sons, Ltd. DOI: 10.1002/0470090456.ch7. URL: https://onlinelibrary.wiley.com/doi/10.1002/0470090456.ch7 (visited on 04/19/2023).

Igan, Deniz, Ali Mirzaei, and Tomoe Moore (Feb. 2023). "A shot in the arm: Economic support packages and firm performance during COVID-19". en. In: *Journal of Corporate Finance* 78, p. 102340. ISSN: 0929-1199. DOI: 10.1016/j.jcorpfin.2022.102340. URL: https://www.sciencedirect.com/science/article/pii/S0929119922001833 (visited on 04/11/2023).

Julin, Ida Rommedahl, Alexander Meldgaard Otte, and Andreas Kuchler (2021). *Firm financing and public support measures during the pandemic*. en. Danmarks Nationalbank Working Papers 184.

KfW (2022). *KfW-Mittelstandspanel 2022*. de. Tech. rep. Frankfurt am Main: KfW Bankengruppe. URL: https://www.kfw.de/PDF/Download-Center/Konzernthemen/Research/PDF-Dokumente-KfW-Mittelstandspanel/KfW-Mittelstandspanel-2022.pdf (visited on 07/04/2023).

Kobrosly, Roni (Aug. 2020). "causal-curve: A Python Causal Inference Package to Estimate Causal Dose-Response Curves". en. In: *Journal of Open Source Software* 5.52, p. 2523. ISSN: 2475-9066. DOI: 10.21105/joss.02523.

URL: https://joss.theoj.org/papers/10.21105/joss.02523 (visited on 04/18/2023).

Kochaniak, Katarzyna, Paweł Ulman, and Robert Zajkowski (July 2023). "Effectiveness of COVID-19 state aid for microenterprises in Poland". en. In: *International Review of Economics & Finance* 86, pp. 483–497. ISSN: 1059-0560. DOI: 10.1016/j.iref.2023.03.038. URL: https://www.sciencedirect.com/science/article/pii/S1059056023001090 (visited on 04/11/2023).

Lalinsky, Tibor and Rozália Pál (2021). "Distribution of COVID-19 government support and its consequences for firm liquidity and solvency". en. In: *Structural Change and Economic Dynamics* 61, pp. 305–335. ISSN: 0954-349X. DOI: 10.1016/j.strueco.2022.03.008. URL: https://www.sciencedirect.com/science/article/pii/S0954349X22000431 (visited on 04/10/2023).

Marek, Philipp and Leo Gärtner (2022). "The Impact of German Public Support Transfers on Firm Finance: Evidence from the COVID-19 Crisis". en. In: *SSRN Electronic Journal*. ISSN: 1556-5068. DOI: 10.2139/ssrn.4156119. URL: https://www.ssrn.com/abstract=4156119 (visited on 04/08/2023).

Moodie, Erica EM and David A Stephens (Apr. 2012). "Estimation of dose–response functions for longitudinal data using the generalised propensity score". In: *Statistical Methods in Medical Research* 21.2. Publisher: SAGE Publications Ltd STM, pp. 149–166. ISSN: 0962-2802. DOI: 10.1177/0962280209340213. URL: https://doi.org/10.1177/0962280209340213 (visited on 04/25/2023).

OCED (Apr. 2021). *One year of SME and entrepreneurship policy responses to COVID-19: Lessons learned to "build back better"*. en. OECD Policy Responses to Coronavirus (COVID-19). Series: OECD Policy Responses to Coronavirus (COVID-19). DOI: 10.1787/9a230220-en. URL: https://www.oecd-ilibrary.org/social-issues-migration-health/one-year-of-sme-and-entrepreneurship-policy-responses-to-covid-19-lessons-learned-to-build-back-better_9a230220-en (visited on 04/14/2023).

Pagano, Marco and Josef Zechner (Aug. 2022). *COVID-19 and Corporate Finance*. en. SSRN Scholarly Paper. Rochester, NY. DOI: 10.2139/ssrn.4185703. URL: https://papers.ssrn.com/abstract=4185703 (visited on 04/14/2023).

Parlapiano, Fabio et al. (2020). *The effects of the COVID-19 shock on corporates' liquidity needs, balance sheets and riskiness*. en. Bank of Italy.

Peichl, Andreas et al. (2021). "Eigenkapitalentwicklung im Zeichen der Coronakrise". de. In: *ifo-Studie im Auftrag der IHK für München und Oberbayern* Impulse für die Wirtschaft.

Piette, Ch and J. Tielens (2022). "How Belgian firms fared in the COVID-19 pandemic ?" In: *Economic Review*. Publisher: National Bank of Belgium, pp. 1–33. URL: https://econpapers.repec.org/article/nbbecrart/y_3a2022_3am_3ajune1.htm (visited on 04/16/2023).

Puhr, Claus and Martin Schneider (2021). "Have mitigating measures helped prevent insolvencies in Austria amid the COVID-19 pandemic?" en. In: *Monetary Policy & the Economy* Q4/20-Q1/21. Publisher: Oesterreichische Nationalbank (Austrian Central Bank), pp. 77–110. URL: https://ideas.repec.org//a/onb/oenbmp/y2021iq4-20-q1-21b4.html (visited on 04/11/2023).

Rosenbaum, Paul R and Donald B Rubin (1983). "The central role of the propensity score in observational studies for causal effects". en. In: *Biometrika* 70.1, pp. 41–55.

Selebaj, Domagoj and Matej Bule (June 2021). "Effects of grants from EU funds on business performance of non-financial corporations in Croatia". en. In: *Public Sector Economics* 45.2, pp. 177–207. ISSN: 2459-8860. DOI: 10.3326/pse.45.2.1. URL: http://www.pse-journal.hr/upload/files/pse/2021/2/1.pdf (visited on 04/25/2023).

Stien, Håkon and Kristoffer Risan (2022). "COVID-19 and Government Aid: An Economy on Life Support? An exploratory study of the effects of deferred tax payments in Norway during COVID-19". eng. Accepted: 2022-08-30T10:32:41Z. MA thesis. URL: https://openaccess.nhh.no/nhh-xmlui/handle/11250/3014324 (visited on 04/14/2023).

Tielens, Joris, Christophe Piette, and Olivier De Jonghe (2020). "Belgian corporate sector liquidity and solvency in the COVID-19 crisis: a post-first-wave assessment". en. In.

Wu, Xiao et al. (Aug. 2021). *Matching on Generalized Propensity Scores with Continuous Exposures*. arXiv:1812.06575 [stat]. URL: http://arxiv.org/abs/1812.06575 (visited on 04/21/2023).

Statement of Authorship

I hereby confirm and certify that this master thesis is my own work. All ideas and language of others are acknowledged in the text. All references and verbatim extracts are properly quoted and all other sources of information are specifically and clearly designated. I confirm that the digital copy of the master thesis that I submitted on 02.05.2023 is identical to the printed version I submitted to the Examination Office on 03.05.2023.

DATE: 02.05.2023

NAME: Marco Schildt

SIGNATURE: