Report

How were Companies Affected During the First and Second Waves of the Corona Pandemic in Switzerland? An Analysis based on KOF Survey Data, Short Term Work and Company Websites

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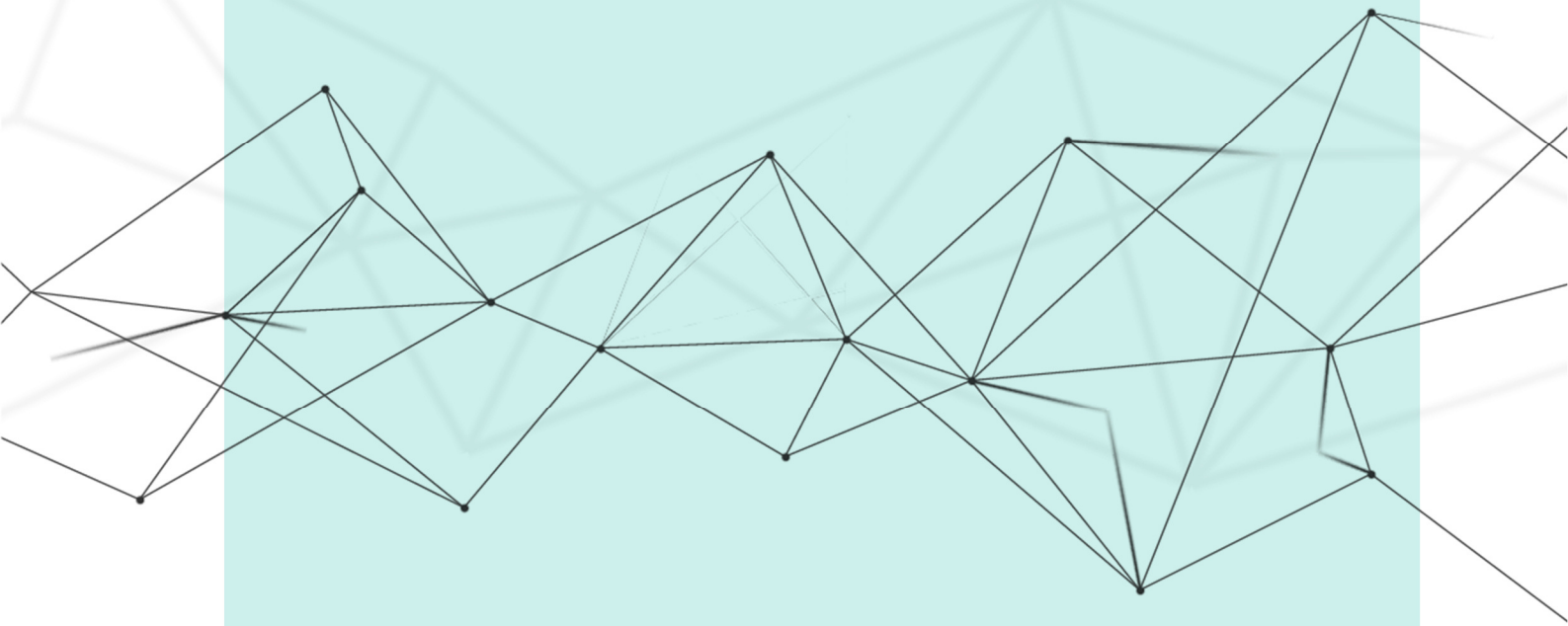

Grundlagen für die Wirtschaftspolitik

In der Publikationsreihe «Grundlagen für die Wirtschaftspolitik» veröffentlicht das Staatssekretariat für Wirtschaft SECO Studien und Arbeitspapiere, welche wirtschaftspolitische Fragen im weiteren Sinne erörtern.

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Anmerkungen
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Wie waren Unternehmen in der Schweiz von der ersten und zweiten Welle der Corona-Pandemie betroffen?

Eine Analyse basierend auf KOF Umfragedaten, Kurzarbeit und Firmenwebseiten

Zusammenfassung

Dieser Bericht analysiert die wirtschaftlichen Folgen der Corona-Pandemie in der Schweiz mit Hilfe moderner Web-Scraping- und Text-Mining-Methoden, die auf Unternehmenswebseiten angewendet werden, zusammen mit Umfragedaten und nationalen Statistiken. In diesem Bericht untersuchen wir Art und Ausmaß der Auswirkungen der Corona-Pandemie auf Schweizer Unternehmen, die Ausbreitung des Pandemieschocks in der Wirtschaft und die wesentlichen Merkmale der Widerstandsfähigkeit eines Unternehmens.

Unsere Analyse basierend auf den KOF-Umfragedaten und den Webseitendaten zeigt, dass in der ersten Welle Produktionsprobleme vor allem bei kleinen und mittleren Unternehmen auftraten (bei fast 10%), während in der zweiten Welle größere Unternehmen stärker betroffen waren. Zudem war gemäß den Webseitendaten und dem Kurzarbeitsbezug das Tessin in der ersten Welle die am stärksten betroffene Region der Schweiz, während in der zweiten Welle regionale Unterschiede weniger ausgeprägt waren. Weiter stellen wir fest, dass die Erwähnungen von Corona-Problemen auf Unternehmenswebseiten positiv mit dem Bezug von Kurzarbeit und der Reduzierung der Arbeitsplatzpräsenz und negativ mit Infektionen (evtl. aufgrund verzögerter Effekte) korreliert sind.

Auf Branchenebene zeigen Daten zur Kurzarbeit, dass die direkt betroffenen Branchen wie Lebensmittel- und Getränkedienstleistungen, Luftverkehr, Beherbergung oder Kunst, Unterhaltung und Freizeit am stärksten von der Krise betroffen sind. Die Umfrage- und Webseitendaten ergänzen dieses Ergebnis, da sie zeigen, dass auch produzierende Branchen, die über eingeschränkte Home-Office Möglichkeiten verfügen und Vorleistungen für direkt betroffene nachgelagerte Branchen produzieren, mit Produktionsproblemen konfrontiert sind.

Bei der Analyse der Widerstandsfähigkeit und/oder Anfälligkeit für Produktions-, Liefer- oder Einkaufsprobleme aufgrund der Corona-Pandemie stellen wir fest, dass Unternehmen, die von der ersten Welle der Pandemie stark betroffen waren, einem starken Preiswettbewerb ausgesetzt sind, exportintensiv sind und Schwierigkeiten bei der Lieferung der Waren haben, die online bestellt wurden. Im Gegensatz dazu sind forschungsaktive Unternehmen, Unternehmen in ausländischem Besitz und Unternehmen mit guter digitaler Infrastruktur weniger betroffen und zeigten daher eine größere Widerstandsfähigkeit gegenüber den Corona-induzierten wirtschaftlichen Turbulenzen.

Darüber hinaus stellen wir in der Schweiz einen signifikanten Einfluss der Corona- Schockausbreitung über die Branchen hinweg fest. Dieser ist von ähnlicher Größe für die Upstream-(Lieferanten) und Downstream-(Kunden) gelagerten Firmen. Der am stärksten betroffene Sektor für die Downstream-Schockausbreitung ist der Reparatur/Installationssektor und der am stärksten betroffene Sektor für die Upstream-Schockausbreitung ist Gummi/Kunststoffherstellung. Für diese Sektoren ist der idiosynkratrische (direkte) Schock geringer als der Upstream-/ Downstream-Schock. Folgend unserer Analyse zur Schockausbreitung sind die am stärksten betroffenen Branchen relativ klein. Während Maßnahmen wie Betriebsschliessungen in Kombination mit der Schwierigkeit, Homeoffice umzusetzen, die Betroffenheit einer Branche direkt erhöhen, führt eine hohe Produktivität einer Branche dazu, die Betroffenheit zu verringern. Darüber hinaus sehen wir, dass indirekte Effekte aus anderen vor- oder nachgelagerten Industrien die Betroffenheit einer Industrie deutlich erhöhen. Die separate Analyse der ersten und zweiten Welle zeigt zudem, dass in beiden Wellen Schockausbreitungseffekte eine wichtige Rolle spielten, die wirtschaftlichen Auswirkungen der Betriebsschliessungen in der zweiten Welle jedoch schwächer waren.

Comment les entreprises ont-elles été affectées lors des première et deuxième vagues de la pandémie de coronavirus en Suisse

Une analyse basée sur les données d'enquête du KOF, le chômage partiel et les sites web des entreprises

Résumé

Ce rapport analyse les conséquences économiques de la pandémie de coronavirus en Suisse à l'aide d'outils modernes de recherche sur le Web et d'extraction de texte appliqués aux sites Web des entreprises, ainsi que des données d'enquête et des statistiques nationales. Dans ce rapport, nous examinons la nature et l'étendue de l'impact de la pandémie de de coronavirus sur les entreprises suisses, la propagation du choc pandémique dans l'économie et les caractéristiques les plus essentielles de la résilience d'une entreprise.

Notre analyse montre que les problèmes de production se sont produits au cours de la première vague principalement parmi les petites et moyennes entreprises (atteignant près de 10%), tandis que dans la deuxième vague, les grandes entreprises ont été plus touchées. De plus, lors de la première vague, le Tessin était la région la plus touchée de Suisse alors que les différences régionales sont moins prononcées lors de la deuxième vague. Nous constatons en outre que les mentions de problèmes liés au coronavirus sur les sites web des entreprises sont corrélées avec la réduction de l'horaire de travail (chômage partiel), la réduction de la présence sur le lieu de travail et négativement avec les infections (peut-être en raison d'un décalage dans le temps).

Au niveau sectoriel, les données sur le chômage partiel montrent que les secteurs directement touchés tels que les services de restauration, le transport aérien, l'hébergement ou les arts, les divertissements et les loisirs ont été les plus durement touchés par la crise. L'enquête et les données du site Web complètent cette conclusion, car elles montrent que les secteurs manufacturiers qui ont des possibilités limitées télétravail et qui produisent des intrants pour les secteurs en aval directement touchés mentionnés ont été confrontés à des problèmes de production.

En analysant la résilience et/ou la vulnérabilité des entreprises aux problèmes de production, d'approvisionnement ou d'achat dus à la pandémie de coronavirus, nous constatons que les entreprises qui ont été fortement touchées par la première vague de la pandémie sont confrontées à une forte concurrence par les prix, exportent beaucoup et ont des difficultés à livrer les marchandises commandées en ligne. En revanche, les entreprises actives en R&D, les entreprises à capitaux étrangers et les entreprises dotées d'une bonne infrastructure numérique sont moins touchées et ont donc fait preuve d'une plus grande résilience aux turbulences économiques induites par le COVID-19.

De plus, nous trouvons un impact significatif de propagation du choc du COVID-19 dans tous les secteurs en Suisse. Il est de taille similaire pour la propagation en amont (fournisseurs) et en aval (clients). Les secteurs les plus touchés pour le choc en aval sont la Réparation/Installation et le secteur le plus touché en amont est le Caoutchouc/Plastiques. Pour ces secteurs, le choc idiosyncratique (direct) est plus faible que le choc amont/aval. Il est également important de voir que les industries les plus touchées selon le modèle de propagation des chocs sont des secteurs relativement petits. Alors que des mesures politiques comme la fermeture du lieu de travail en combinaison avec la difficulté télétravail augmentent directement l'impact d'une industrie, la productivité d'une industrie a tendance a la diminuer. De plus, nous voyons que les effets indirects d'autres industries, en amont ou en aval, augmentent considérablement l'incidence de l'industrie focale. L'analyse séparée des première et deuxième vagues montre que si les effets de propagation des chocs ont joué un rôle important dans les deux vagues, l'impact économique de la politique (fermeture des lieux de travail) a été atténué lors de la deuxième vague.

In che modo sono state colpite le aziende durante la prima e la seconda ondata della pandemia di corona in Svizzera?

Un'analisi basata sui dati dei sondaggi KOF, sulla disoccupazione parziale e sui siti web aziendali

Riassunto

Questo rapporto analizza le conseguenze economiche della pandemia Corona in Svizzera utilizzando moderni strumenti di web-crawling e text-mining applicati ai siti web delle aziende insieme a dati di sondaggi e statistiche nazionali. In questo rapporto esaminiamo la natura e la portata dell'impatto della pandemia Corona sulle aziende svizzere, la propagazione dello shock pandemico nell'economia e le caratteristiche più essenziali della resilienza di un'azienda.

La nostra analisi mostra che i problemi di produzione si sono verificati durante la prima ondata prevalentemente tra le piccole e medie imprese (raggiungendo quasi il 10%), mentre nella seconda ondata le grandi imprese sono state maggiormente colpite. Inoltre, durante la prima ondata il Ticino

è stata la regione più colpita della Svizzera, mentre le differenze regionali sono meno pronunciate nella seconda ondata. Scopriamo inoltre che le menzioni del problema Corona sui siti Web aziendali sono correlate alla disoccupazione parziale (Kurzarbeit), alla riduzione della presenza sul posto di lavoro e correlate negativamente alle infezioni (probabilmente a causa di un sfasamento temporale).

A livello settoriale, i dati sulla disoccupazione parziale mostrano che i settori direttamente colpiti come i servizi di ristorazione, trasporto aereo, alloggio o arte, intrattenimento e ricreazione sono stati i più colpiti dalla crisi. L'indagine e i dati del sito web completano questo risultato, in quanto mostrano che anche i settori manifatturieri che hanno possibilità limitate di home office e che producono input per i suddetti settori a valle direttamente interessati hanno dovuto affrontare problemi di produzione. Analizzando la resilienza e/o la vulnerabilità dell'azienda a problemi di produzione, fornitura o acquisto a causa della pandemia Corona, troviamo che le aziende che sono state pesantemente colpite dalla prima ondata della pandemia affrontano una forte concorrenza sui prezzi, esportano ad alta intensità e hanno difficoltà a consegnare le merci ordinate online. Al contrario, le società attive in ricerca e sviluppo, le società di proprietà straniera e le società con una buona infrastruttura digitale sono meno colpite e hanno quindi mostrato una maggiore resilienza alle turbolenze economiche indotte dal COVID. Inoltre, troviamo un significativo effetto di propagazione dello shock Covid in tutti i settori in Svizzera.

E` di dimensioni simili per la propagazione a monte (fornitori) e a valle (clienti). I settori più colpiti dallo shock a valle sono Riparazione/Installazione e il settore più colpito a monte è Gomma/Plastica. Per questi settori lo shock idiosincratico (diretto) è minore dello shock upstream/downstream. E` anche importante vedere che le industrie più colpite secondo il modello di propagazione degli shock sono settori relativamente piccoli. Mentre le misure politiche come la "chiusura del posto di lavoro" in combinazione con la "difficoltà del lavoro a casa" aumentano direttamente l'incidenza di un'industria, la produttività di un'industria tende a ridurla. Inoltre, vediamo che gli effetti indiretti di altre industrie, a monte o a valle, aumentano significativamente l'incidenza dell'industria focale. L'analisi separata della prima e della seconda ondata mostra che mentre gli effetti di propagazione degli shock hanno svolto un ruolo importante in entrambe le ondate, l'impatto economico della politica (chiusura del posto di lavoro) è stato attenuato nella seconda ondata.

How were Companies Affected During the First and Second Waves of the Corona Pandemic in Switzerland?

An Analysis based on KOF Survey Data, Short Term Work and Company Websites

Summary

This report analyzes the economic consequences of the Corona pandemic in Switzerland using modern web-scraping and text-mining tools applied to company websites together with survey data and national statistics. In this report we examine the nature and extent of the impact of the Corona pandemic on Swiss companies, the propagation of the pandemic shock in the economy and the most essential characteristics of a company's resilience.

Our analysis based on website and survey data shows that production problems occurred during the first wave predominantly among small and medium sized companies (reaching almost 10%), while in the second wave large firms were more affected. Moreover, according to website and short time work data during the first wave Ticino was the most affected region in Switzerland while regional differences are less pronounced in the second wave. We further find that Corona problem mentions on company websites are positively correlated with short term work (Kurzarbeit) and the reduction in work place presence, and negatively correlated with infections (possibly due to a time lag).

At the sectoral level short time work data shows that the directly affected sectors such as food and beverage services, air transport, accommodation or arts, entertainment and recreation have been strongest hit by the crisis. The survey and website data complement this finding, as they show that also manufacturing sectors that have limited home office possibilities and that produce inputs for the mentioned directly affected downstream sectors have been confronted with production problems.

Analyzing firm resilience and/or vulnerability to production, supply or purchasing problems due to the Corona pandemic, we find that companies that were heavily affected by the first wave of the pandemic face strong price competition, are export intensive and have difficulties delivering the goods ordered online. In contrast, R&D-active companies, foreign-owned companies and companies with good digital infrastructure are less affected and thus showed greater resilience to COVID-induced economic turbulence.

Further, we find a significant Corona shock propagation effect across sectors in Switzerland. It is of similar size for upstream (suppliers) and downstream (customers) propagation. The most affected sectors for the downstream shock is Repair/Installation and the most affected sector upstream is Rubber/Plastics. For these sectors the idiosyncratic (direct) shock is smaller than the upstream/downstream shock. It is also important to see that the most affected industries according to the shock propagation model are relatively small sectors. While policy measures like "work place closure" in combination with "difficulty of home office" directly increase the affectedness of an industry, the productivity of an industry tends to decrease it. Moreover, we see that indirect effects from other industries, upstream or downstream, increase the affectedness of the focal industry significantly. Analyzing the first and second waves separately shows that while shock propagation effects played an important role in both waves, the economic impact of the (work place closure) policy was attenuated in the second wave.

Contents

1 Introduction and Research Question

The COVID-19 pandemic has claimed the lives of nearly 5 million people worldwide (as of September, 2021). To slow down the spread of COVID-19, governments in China, Europe, the U.S., and beyond have taken drastic measures, such as travel warnings, border and store closures, regional lockdowns, and curfews. A recent and growing literature has studied the effectiveness of these policy measures to slow the growth rate of infections (see e.g. Gibney, 2020; Hsiang et al., 2020; Fang et al., 2020; Friedson et al., 2020). However, these studies are typically constrained to the early stages of the pandemic or consider only a subset of selected countries or regions. They therefore lack a comprehensive view that allows for a inter-temporal or inter-regional comparison of different policies.

The policy measures that have been implemented in response to the Corona pandemic are also having drastic consequences for personal freedom and the economy (Acemoglu et al., 2020; Brodeur et al, 2021). Some sectors, such as airlines or accommodations, faced a nearly complete breakdown of demand (Baldwin and di Mauro, 2020). The Corona pandemic led to the largest global recession of the last nine decades (Brodeur et al, 2021; Baldwin & di Mauro, 2020; Acemoglu et al., 2020). Cutler & Summers (2021) estimate the total cost of the pandemic for the US to be more than $16 trillion, or approximately 90% of the annual gross domestic product of the US. The OECD (2020) forecasts a fall in global GDP by 6 to 7.6%. Bloom et al. (2020) estimate that COVID-19 will reduce productivity in the private sector by up to 5% in the last quarter in 2020.

Given these drastic health and economic consequences of the Corona pandemic, policy makers around the world launched some of the largest economic support programmes in history. In order to design such support programs in the most effective way, they should be targeted towards the hardest hit companies, sectors and regions.

Economic data on the affectedness of companies and sectors are however in most cases available only with a certain time lag. This study therefore investigates how different data sources can provide timely indications on the affectedness of companies and sectors from the corona pandemic.

In this report we use short time work data, survey data but also modern data analytics and text mining techniques combined with access to novel digital data sources. In particular, we analyze if this technique can indicate the affectedness of companies from the Corona pandemic by measuring Corona mentions on the companies' websites in Switzerland. If so the case, this would allow to measure corona affectedness in real time.

This report is organized as follows. Section 2 provides a brief discussion of the related literature. The various data sources and the methods for their analysis are described in Section 3. The results and a comparison to other data sources are presented in Section 4. In particular, Section 4.1 analyzes difference across industries, while Section 4.2 analyzes difference across regions. Firm characteristics that contribute to resilience, respectively vulnerability from the pandemic shock are discussed in Section 5. The Corona shock propagation effects within the production network are analyzed in Section 6. Finally, Section 7 concludes. Additional relevant material can be found in the Data Appendix.

2 Related Literature

While in the early phase of the pandemic already a growing number of studies analyzing (and modeling) the health impact of the Corona pandemic, the economic consequences are documented only with a lag of 1 or 2 years. A small number of recent studies has tried to use novel digital data

sources to measure the economic impact of the pandemic. Examples that try to identify firm-level exposure to the Corona pandemic include Stephany et al. (2020), who use company risk reports, and Hassan et al. (2020), who use quarterly earnings reports of stock market listed companies in the U.S.. In this project we apply similar data analytic techniques but at a much broader scale by using the information on companies' websites to study whether and how firms are affected by the pandemic across sectors, regions and over time (see König and Wörter, 2020, for a pilot study). The text relating to the Corona pandemic can be analyzed for thematic areas (such as production, supply or purchasing problems) and sentiments of Corona-related paragraphs via sentiment analysis (Vossen et al., 2016). In combination with survey data and other relevant data sources this will give a more comprehensive and up-to-date picture of the economic consequences of the Corona pandemic in Switzerland.

3 Method and Data Sources

We use several data sources to respond to the above mentioned research questions and to analyze the economic impact of the Corona pandemic in Switzerland, including company websites (Section 3.1), survey data (Section 3.2), COVID-19 infection statistics (Section 3.3), information on bankruptcies and liquidations (Section 3.4), short term work/Kurzabreit (Section 3.5), various data from the Swiss Federal Statistical Office (Section 3.6) and data on work place presence (Section 3.7). These various data sources and the methods used to construct them are explained in greater detail in the following sections.

3.1 Website Data

Data source. Around 50 thousand websites of companies in Switzerland were examined once a week for the occurrence of the word "Corona" or its synonyms across two waves from April 2020 to June 2020 and from October 2020 to March 2021. The websites (domains) were made available by the KOF Swiss Economic Institute and comprises the majority of companies in Switzerland with more than five employees in the manufacturing, construction and services sectors which maintain their own website. Since almost all firms have websites nowadays the expected degree of coverage is therefore very high.[1] The analysis considers the three national languages French, Italian and German as well as English websites.

The websites of the companies are queried and downloaded using the Automated Robot for Generic Universal Scraping (ARGUS). This web-scraping tool performs tasks like scraping texts, collecting hyperlinks between websites, keywords, titles and more, based on the Scrapy Python framework (ARGUS, 2020). A maximum of ten sub-websites per company are downloaded. The selection of these sub-websites is not random but follows a simple heuristic. First sub-websites are selected that are written in French, Italian or German and that have the shortest URLs. The latter leads to prioritized sub-websites with more general and up-to-date (top-level) information. For example, "kof.ethz.ch/news-und-veranstaltungen" is therefore queried before "kof.ethz.ch/news-und-veranstaltungen/medien.html". Overall, 82.2% of the original websites were successfully queried and downloaded. The failed attempts are out of date and permanently or temporarily deactivated

[1] See Tables 12 and 11 in the Appendix A.2 for further details of the website-based sample representativeness.

websites. For our analysis we further use only websites that were updated at least once during the observation period.[2]

The downloaded websites are then searched for the term Corona or variations of it (e.g. COVID-19). In the event of a hit, the respective paragraph is identified and processed for further analysis. This simple procedure allows a first assessment of the proportion of companies that are writing about the Corona pandemic on their website. Where required, the Corona mentioning paragraphs are then translated into English (from German, French, and Italian) using Google's Cloud translation service.The paragraphs are then further processed using computer-based text analysis algorithms (text-mining and natural language processing tools) in order to capture the sentiment and context or problem topic of the Corona mention.

Sentiments. To analyze companies' opinions, attitudes and evaluations of the Corona pandemic we identified whether the Corona mentioning paragraph on a company website has a negative *sentiment* by applying a computational procedure that can detect subjectivity in texts (Hutto & Gilbert, 2014). We used the *spaCy* and the rule-based *TextBlob* packages which are available for processing multiple languages. These packages contain advanced Natural Language Processing (NLP) tools implemented in Python. The packages load the text, search for a specific language, and pre-process the text into this language accordingly. These are state of the art algorithms that can handle large data sets, require no training data and can take different languages into account. The output of the sentiment analysis algorithms provides a sentiment polarity score of a text, measuring the positivity and negativity in a text. The polarity lies in the range of $[-1, +1]$, where a score below zero indicates a negative statement, zero a neutral statement, and a score above zero a positive statement.

The data can then be represented by a *Word Cloud*. This is a visualization technique of textual data in which the size of a word indicates the importance or the frequency of its occurrence in the text. Before constructing such a Word Cloud, some pre-processing of the data is necessary. After removal of punctuation, case alignment and stop word (e.g. "the", "a" and "than"), the remaining tokens were lemmatized. Lemmatization reduces inflected forms of a word back to its root form - the 'lemma'. For example, "running", "runs" and "ran" are all different versions of the root word "run".

Figure 1 shows the Word Cloud for the negative sentiments detected in the Corona mentioning paragraphs on company websites in Switzerland. Negative sentiments on the website are often seen in the context of federal measures ("Federal Council", "Crisis") and refer to temporary closures ("close", "remain closed", "current") and cancellations.

Problem topics. We identified different problem topics in the Corona mentioning paragraphs with a rule based approach using keywords (extending Hassan et al., 2020, and Stephany et al., 2020). These problem topics with examples and corresponding Word Clouds are listed in the following:

a) Production: We identified 35 keywords related to production problems (with 8925 occurrences).[3] An example is given below:

[2] In Appendix A.2.2 we use an alternative datasource in which only websites that are frequently updated can be analyzed.

[3] **Keywords (occurrences):** work (3288), employee (2436), operation (994), project (717), production (623), product (612), site (596), closure (355), facility (354), store (275), labor (218), capacity (216), innovation (198), produce

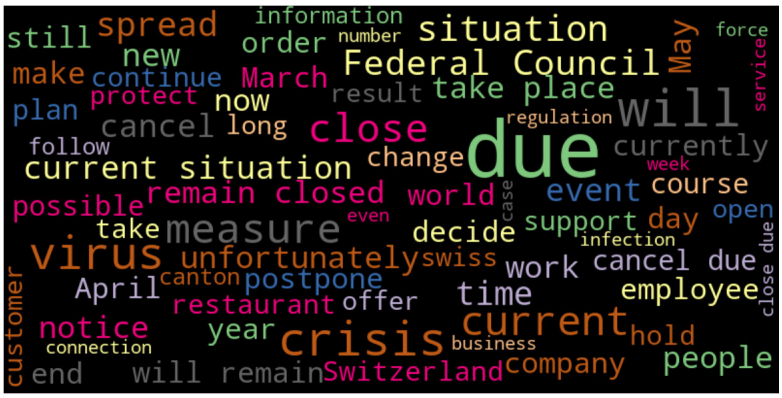


Figure 1: Word cloud showing the keywords related to negative sentiments (with COVID synonyms removed).

> "*... Beckhoff is reintroducing reinforced security measures due to the COVID19 infection. From Monday, October 26, 2020, the tried and tested two-shift system in production and an 80/20 home office rule for office workplaces will apply again.*"

Figure 2 illustrates the Word Cloud for the production problem category. Production problems are often mentioned in connection with employment, health, work or operations in general ("work", "operation") and once more with "measures" and closures ("close"). Furthermore, the temporary character ("current situation") is also emphasized and reference is made to the order situation ("order").

b) Demand: We identified 29 keywords related to demand problems (5737 occurrences).[4] An example is given below:

> "*... Dear customers, due to the uncertainty about the development of the pandemic, we are closing the restaurant, the shop and the reception until the end of March.*"

Figure 3 illustrates the Word Cloud for the demand problem category. Demand problems are expressed by the order ("order", "sale") and are often related to the measures of the Federal Council ("measures") and closures ("close") of possibly other companies ("customer"). The

(196), plant (152), laboratory (151), factory (142), manufacturing (104), workforce (83), shutdown (81), operating (74), business operation (65), shut down (59), safety measure (56), business activity (50), inventory (27), productivity (21), utilization (10), close down (7), throughput (5), employee productivity (4), business disruption (2), R&D (1), mode of operation (1), manufacturing operation (1).

[4]**Keywords (occurrences):** customer (2581), sale (741), demand (684), delivery (585), client (332), cancellation (317), income (297), consumer (278), store (271), purchase (180), retail (158), booking (111), revenue (86), volume (80), segment (53), business activity (50), transaction (49), sentiment (33), attendance (29), consume (27), e–commerce (24), market condition (18), subscriber (18), billing (16), consumer confidence (8), store closure (4), distribution channel (4), consumer demand (3), consumer spend (1).

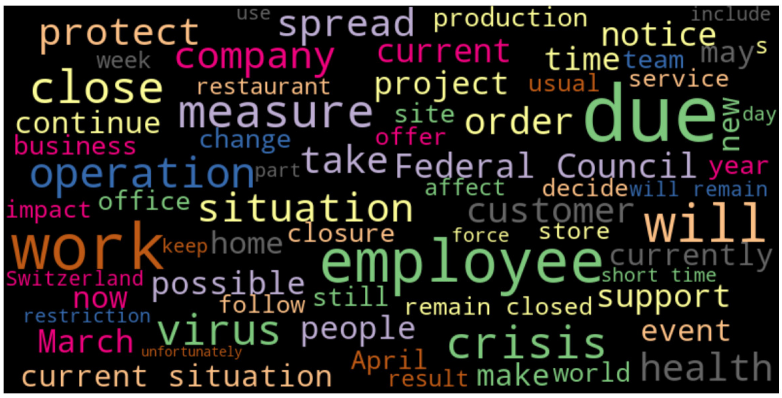


Figure 2: Word cloud showing the keywords related to production problems (with COVID synonyms removed).

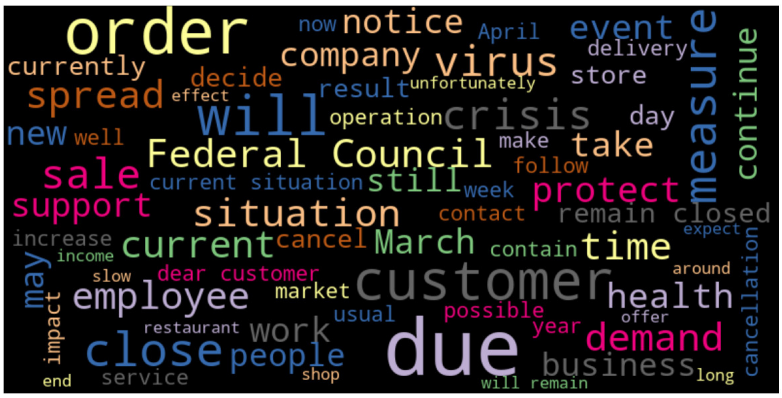


Figure 3: Word cloud showing the keywords related to demand problems (with COVID synonyms removed).

reference to the current situation ("situation", "current") may indicate the temporary nature of the problems.

c) Finance: We identified 16 keywords related to financing problems (2062 occurrences).[5] Two examples are given below:

> "*... In the Corona crisis, financing is drying up for our startup and the Federal Council is taking its time with help.*"

> "*...Since the Corona crisis is far from over, Zurich Airport also puts ensuring*

[5]**Keywords (occurrences):** fund (459), loan (409), credit (301), provision (264), capital (212), liquidity (207), finance (197), debt (166), cash (129), funding (103), equity (89), financing (67), financial impact (16), payment deferral (1), stock price (1), financial asset (1).

Figure 4: Word cloud showing the keywords related to financing problems (with COVID synonyms removed).

liquidity above all else. The waiver of dividends is also a politically sensible signal."

Figure 4 illustrates the Word Cloud for the financing problem category. They are often mentioned in connection with the Federal Council, the availability of financial resources ("funds") and the provision of loans ("Federal Council", "provision", "loan", "credit").

d) Supply: We identified 7 keywords related to supply problems (1233 occurrences).[6] An example is given below:

> "*... The measures ordered by the Federal Council to contain the coronavirus pandemic and the associated current situation are a challenge for everyone. We strive to maintain our operations and our services. We have no influence on foreign suppliers if material is retained or blocked at the border, despite other statements in the media. We therefore regret if some products are not available as a result.*"

Figure 5 illustrates the Word Cloud for the supply problem category. They are naturally related to suppliers, the delay of deliveries ("delay", "delivery" and problems with the supply chain to serve the customers ("chain", "supply", "customers"). Again they seem to emphasis the transient nature of the problems ("current").

e) Travel: We identified 7 keywords related to travel problems (629 occurrences).[7] An example is given below:

> "*... Due to the severely restricted travel options due to the coronavirus, we are currently only able to look after very few of our customers personally on site.*"

[6] **Keywords (occurrences):** supply (444), supply chain (287), delay (284), supplier (283), component (43), procurement (37), purchasing (18).

[7] **Keywords (occurrences):** travel (718), border (222), train (191), rail (38), plane (25), air travel (5), airline industry (4).

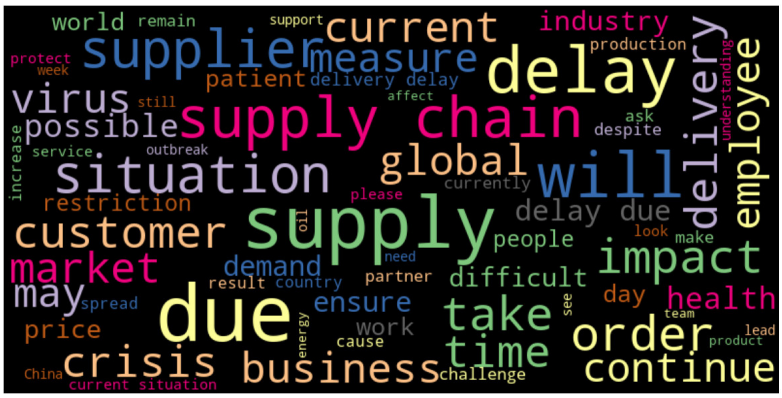


Figure 5: Word cloud showing the keywords related to supply problems (with COVID synonyms removed).

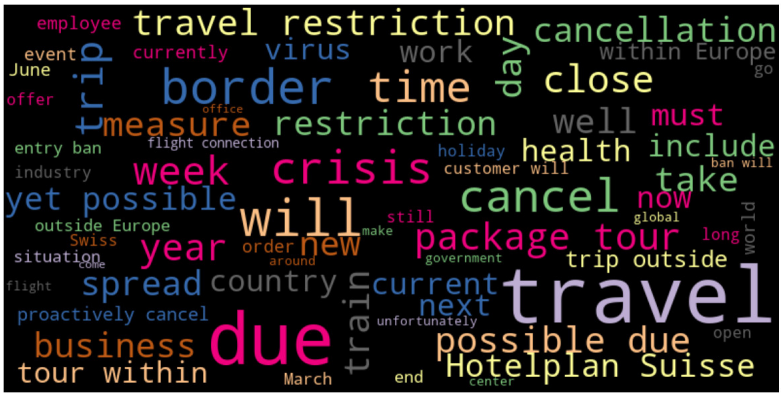


Figure 6: Word cloud showing the keywords related to travel problems (with COVID synonyms removed).

Figure 6 illustrates the Word Cloud for the travel problem category. They are mainly related to border restrictions ("border") in connection with travel by train and air plane ("train", "plane"), but also to the cancellation of trips ("cancellation", "Hotelplan Suisse").

f) Finally, we also computed an overall measure of Corona problem affectedness with an indicator that indicates whether at least one flag from a) to e) above has been identified on a company's website.

More formally, a company website has been flagged as being affected by a problem category i according to:

$$\text{Flag}_i \;=\; \text{Corona } \texttt{AND } \text{ keyword}_i \texttt{ AND } \text{negative sentiment} \tag{1}$$

where "Corona" is an indicator for the word Corona or one of its synonyms, " keyword" represents on of the keywords related to the problem topics from a) to e) above, and "negative sentiment"

indicates that the respective paragraph has a negative sentiment polarity score.

3.2 Survey Data

Corona-relevant information was collected in the KOF Innovation Survey and the KOF Investment Survey. Both surveys are based on the KOF Enterprise Panel and were conducted in June/July 2020. They therefore cover the first COVID wave in Switzerland. The KOF Enterprise Panel is a stratified random sample, where stratification is according to 3 size classes (small, medium-sized, large companies) and 34 economic sectors (WK08 groups, see table 17 in the appendix). The KOF Enterprise Panel comprises companies with more than 5 employees (in full-time equivalents). For the KOF innovation survey, the 7 greater regions of Switzerland were introduced as an additional stratification feature. Thus, representative statements can be made for this 7 greater regions (Lake Geneva Region, Espace Mittelland, Northwestern Switzerland, Eastern Switzerland, Central Switzerland, Zurich, Ticino), too.

The KOF Innovation survey was sent to around 8400 Companies (including the additional companies to gain representativeness on the regional level). For Switzerland the response rate was about 29% and for the region the response rates fluctuate between 23 percent (Lake Geneva Region) and 30 percent (Eastern Switzerland). For more details about the sample, responses and response rates according to industries, firm-size classes and the 7 greater regions see the appendix.

The KOF Investments survey was sent to around 11000 companies. The higher number of companies in this survey is due to the special interest in certain sectors (e.g. the construction sector), for which a higher number of companies were drawn from the population. The response rate in this survey was 29%, too. Stratification in this survey is on two-digit industries and within each industry on the three firm-size classes. For more details about the sample and response rates according to industries and firm-size classes see the appendix.

The KOF Innovation survey includes questions on the extent that a company is affected along their value chain (purchasing - production - supply), the possibility of having employees work from home, and whether the company had to close due to regulations.

Companies were asked on a 4-point Likert scale whether they were affected by the pandemic in purchasing, where we distinguish between the national and international levels, in their production and in supply/delivery, where we also distinguish between the national and international levels.

The KOF Investment survey includes a "home office" related question. Companies responded whether the physical presence of workers at the place of work is necessary for their production or service provision. Companies could choose between three possible answers: a) Physical presence is required in the majority of cases. b) Home work is partly possible, but there is also a physical presence requirement. c) Home work is possible in the majority of cases. This survey also includes a question about the extent the production or service provision was affected by the government-imposed closures in spring 2020. Companies could choose again between three possible answers: a) Our company was completely closed. b) Our company was partially closed, but never completely. c) Our company was fully operational.

The questionnaires for both surveys were sent directly to CEOs (smaller companies) and CFOs (larger companies). This ensures that managers with a good overview of the company respond to these questions.

Figure 7 shows the responses of firms broken up by firm size classes. We observe that between 8% (large) and 13% (small) of the companies have been closed at some times during the first wave

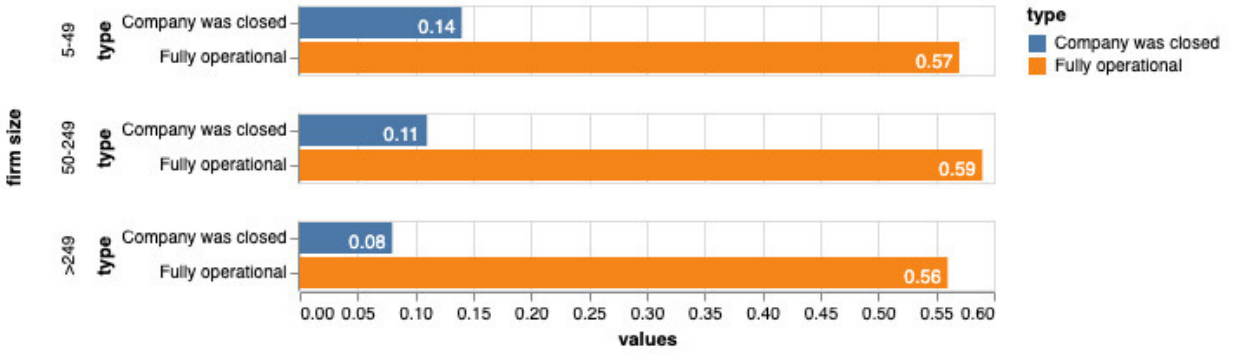


Figure 7: KOF investment survey responses by firm size (during the first wave of the pandemic).

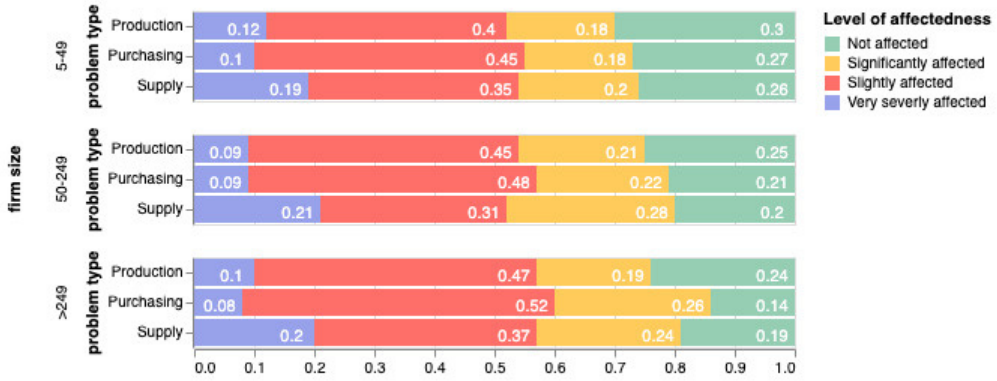


Figure 8: KOF innovation survey responses by firm size (during the first wave of the pandemic). Firms indicated whether they experienced a production, purchasing or supply (i.e. sales/delivery) problem during the first wave of the pandemic.

of the pandemic.

Figure 8 shows the firms' responses broken down by firm size classes. Medium sized enterprises (between 50 and 250 employees) is the firm size class that experienced the largest fraction of firms (more than 60% affected firms) being significantly or severely affected overall (levels 3 or 4). Moreover, large firms (with more than 250 employees) most frequently experienced major supply and purchasing problems (exceeding 80% of affected firms). The reason why large companies were affected more frequently could be that they are more strongly integrated into international supply chains and therefore experienced procurement and delivery difficulties more often.

3.3 COVID-19 Infection Statistics

We use information from the Federal Office of Public Health of the Swiss Confederation (Bundesamt für Gesundheit; BAG) to obtain information about the numbers of infected, hospitalized or deceased from the Corona pandemic in Switzerland. An illustration of the epidemiological dynamics from a

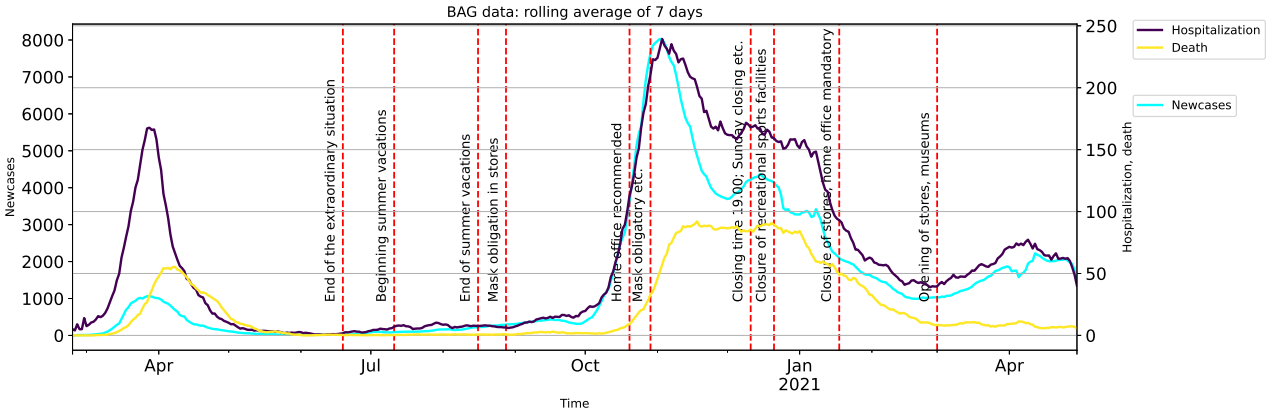


Figure 9: New cases, hospitalizations and deaths from a rolling average over 7 days over the time period considered in this report (source: BAG). Vertical lines indicate different policy interventions.

rolling average over 7 days can be seen in Figure 9.[8] Vertical lines indicate different policy interventions. Two waves can be identified, the first with a peak of infections in April 2020 and the second starting in October 2020.

3.4 Bankruptcies and Liquidations

We use information about firms filing for bankruptcy or in liquidation in Switzerland in the years 2020 and 2021 obtained from Moneyhouse.[9] Analyzing the fraction of firms filing for bankruptcy or being in liquidation over time shows that small firms were more affected, but that there does not seem to be a strong correlation with the epidemic dynamics shown in Figure 9, possibly due to bridging credits made available by the government to firms in financial distress.[10] For this reason we do not perform a more in depth analysis of the bankruptcies and liquidations data, except for computing basic correlations with other data sources.

3.5 Short Term Work (Kurzarbeit)

We use information on short term work (Kurzarbeit) during the Corona pandemic in Switzerland obtained from the State Secretariat for Economic Affairs (SECO).[11] Figure 10 shows the extend of short term work across time and firm sizes. Plotted is the share of hours lost due to short term work as a share of total hours worked. We observe that small firms with less than 10 employees have been affected most according to the short term work data. The effect was strongest during the first wave of the pandemic.

[8] https://www.covid19.admin.ch/en/overview

[9] https://www.moneyhouse.ch/

[10] To ensure liquidity, companies affected by the Covid-19 crisis were eligible to apply for bridging credits guaranteed by the federal government between March 26th 2020 and July 31st 2020. See also https://covid19.easygov.swiss.

[11] https://www.amstat.ch/

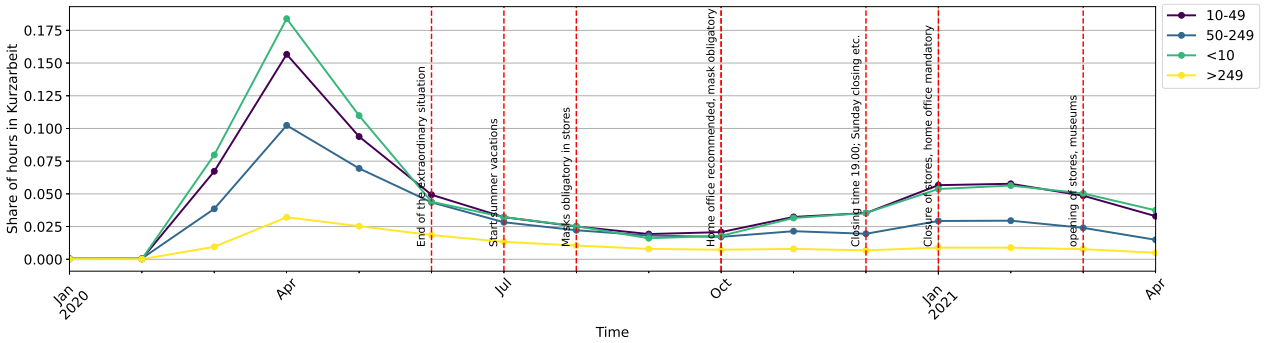


Figure 10: Hours lost due to short term work (Kurzarbeit) as a share of total hours worked across firm sizes and time. Vertical lines indicate different policy interventions.

3.6 Swiss Federal Statistical Office (BFS)

We use several data sets from the Swiss Federal Statistical Office (Bundesamt fÃŒr Statistik, henceforth BFS): 1) Number of employees and full time equivalents per industry, firm size class, and canton, 2) real value added and total use[12] per industry, 3) input-output tables on the flow of goods and services between sectors, 4) number of closed workplaces per industry due to Covid-19 regulations. All of these data sets are publicly available on the BFS website.[13]

3.7 Google Mobility

We use information on changes in work place presence obtained from the COVID-19 Community Mobility Reports provided by Google (Alphabet).[14] The variation of work place presence over time is shown in Figure 11. We observe a steep decline in April 2020, at about the same time as the first wave of infections shown in Figure 9. Because of the high level of aggregation of the mobility data we do not perform a more in depth analysis, except for computing basic correlations with other data sources.

[12]Total use is the sum of contributions to all domestic sectors (including the focal sector), household consumption, and exports.

[13]https://www.bfs.admin.ch/bfs/en/home.html

[14]https://www.google.com/covid19/mobility/

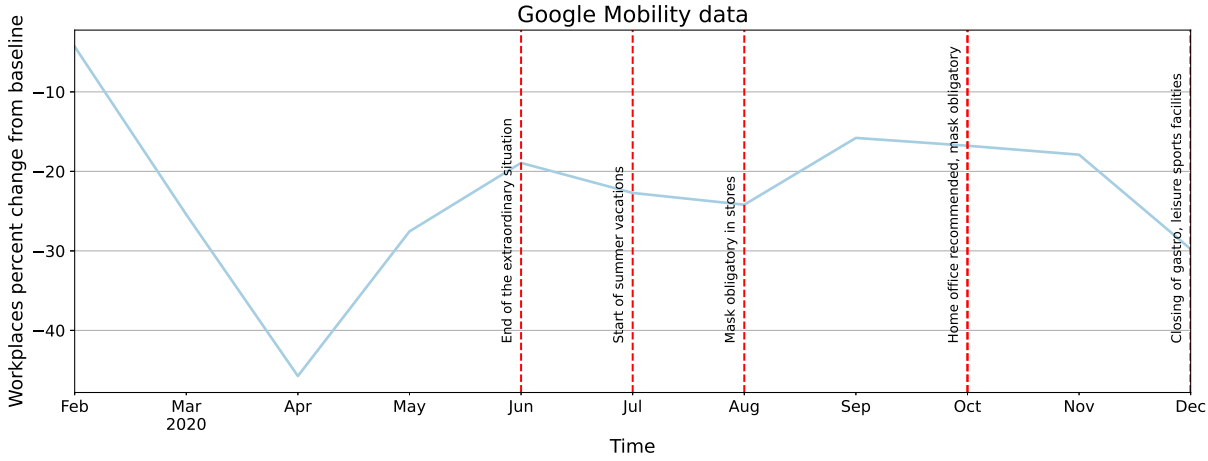


Figure 11: Changes in work place presence (source: Google Mobility Report). Vertical lines indicate different policy interventions.

4 Results and Comparison to Other Data Sources

Not all firms are affected in the same way from the Corona pandemic. Differences exist between firms operating in different industries (sectors) or regions, as well as how these firms are affected over time. We explore these different dimensions in the following sections using alternative data sources.

4.1 Corona Affectedness by Industries

In the following sections we analyze differences across industries in short term work, the survey responses as well as the website text analysis.

4.1.1 Short Term Work

Among the different sectors using short term work illustrated in Figure 12, the five most affected were accommodation/Restaurants, arts, entertainment, and recreation, textiles/clothing, transportation, electronic and optical products. The data for all sectors can be found in Table 18 in the Appendix. Moreover, an overview of how the different industry groups are composed can be found in Table 17.

We observe that in the first wave of the pandemic apart from the services sectors (such as accommodation/restaurants) also the manufacturing sectors (such as electronic and optical products) were heavily affected. The latter seems to be due to the strong export orientation (and the shock to demand on foreign markets) of these manufacturing sectors. In the second wave of the pandemic these manufacturing sectors were much less affected, while the most affected sectors were restaurants, accommodations and the transportation sector.

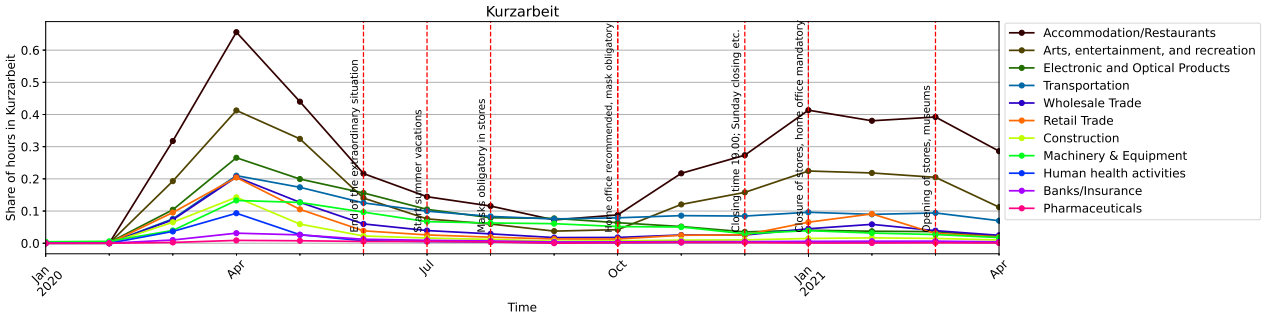


Figure 12: Hours lost due to short term work (Kurzarbeit) as a share of total hours worked (BFS data), across sectors and time. Vertical lines indicate different policy interventions.

4.1.2 Survey Data

Investment survey. The KOF investment survey asks firms to what extent their production or service provisions were affected by the government-imposed closures in spring 2020 in Switzerland (see also Section 3.2). Firms were asked whether they were completely closed at times, partially closed at times but never completely closed, or fully operational. The survey responses show that in total 12% of the companies (with more than 5 employees in full-time-equivalents) were temporarily completely closed due to official regulations. This also includes companies that had to close temporarily due to corona cases in the company and not only companies that had to be closed preventively, e.g. restaurants. 30% of the companies were partially closed, but never completely, and 58% were fully operational.

Figure 13 shows the 5 most affected industries, with Accommodation/Restaurants (2-digit industry level), Personal Services (2-digit industry level) and Watches/Clocks (4-digit industry level) being the three sectors with the largest fraction of firms being closed at some times during the first wave. These closures may have been caused either directly by official regulations or indirectly by corona cases in the company or by difficulties in the supply of production resources. Accommodation/Restaurants and Personal Services are also the two sectors with the largest fractions of firms requiring work place presence.

Innovation survey. The KOF innovation survey is based on a representative sample (size, sector, FSO regions) of companies with more than five employees (see also Section 3.2). In this survey firms were asked whether they experienced problems with purchasing goods domestically or internationally (input), problems with the production of goods and services, or/and problems with supplying goods to domestic or international customers (output) in spring 2020.

Figure 14 shows the 5 most affected industries (according to the overall measure of affectedness, that is, being significantly or severely affected): Basic Metals, Vehicles, Paper, Watches/Clocks, and Electronic and Optical Products. For example, for Electronic and Optical Products all problem categories (supply, production and purchasing) reach 90% of firms being either slightly, significantly or severely affected by the Corona pandemic in spring 2020. This is fairly consistent with the results we have seen for short term work (Kurzarbeit), where Electronics and Optical Products was the most affected sector (after Accommodation/Restaurants) during the first wave of the pandemic.

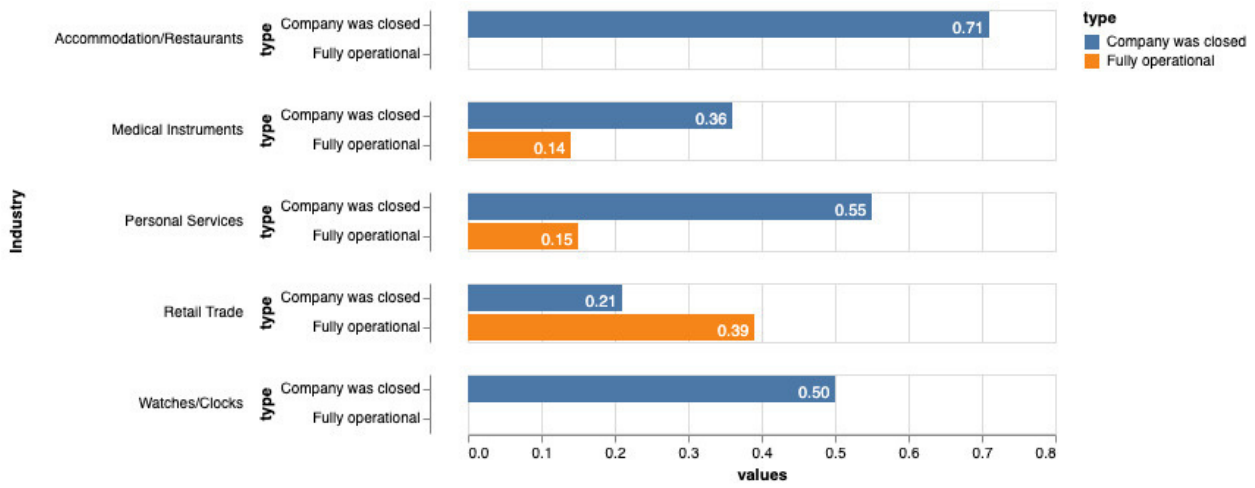


Figure 13: KOF investment survey responses by industry (top five by closure) during the first wave of the pandemic.

Differences from the results according to short-time work registrations, however, could be due to the fact that labor intensity differs by industry. For example, the service and construction sectors tend to be more labor-intensive and may therefore have registered for short-time work more frequently than manufacturing sectors. In addition, customer contact is greater in many service industries. This made it more difficult to maintain operational activities and might result in more short time work registrations. The reason why Accommodation/Restaurants do not appear as a severely affected industry probably has to do with the fact that they were closed and thus had, for example, hardly any procurement or production problems.

Figure 15 shows the 5 least affected industries (according to the overall measure of affectedness, that is, being significantly or severely affected): Technical Commercial Services, Banks/Insurances, Telecommunications, Water/Environment and Energy. In the Energy sector, for example, most firms that experienced a problem in either supply, production or demand, were only slightly affected by the Corona pandemic in spring 2020.

Comparison across data sources. The correlations of the survey results across topics and data sources (across sectors) are shown in Figure 16. We observe that Corona problem topics are highly correlated with each other and with short term work (Kurzarbeit), but uncorrelated with bankruptcies. Moreover, the closure of workplaces correlates highly with the survey response variable "Company was closed" of the KOF investment survey, and also – but to a lesser extent – with the production problem variable identified in the KOF innovation survey.

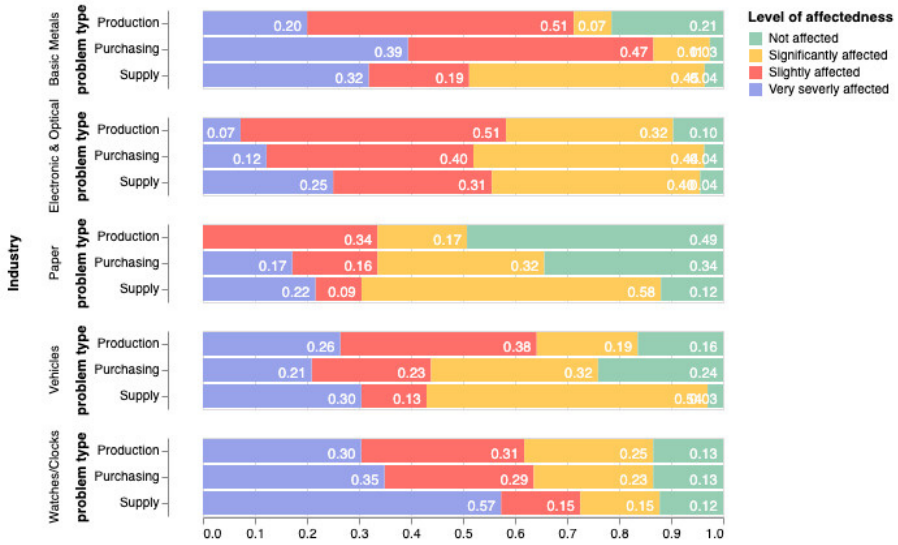


Figure 14: KOF innovation survey responses by industry (top five). Firms indicated whether they experienced a production, purchasing or supply (i.e. sales/delivery) problem during the first wave of the pandemic. For a complete overview across all industries see Figure A.2 in the Appendix A.1.4.

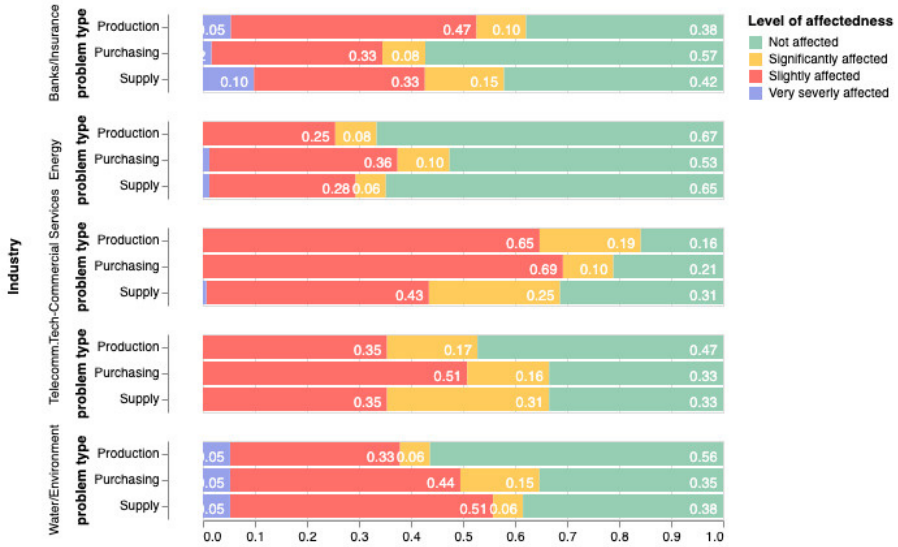


Figure 15: KOF innovation survey responses by industry (bottom five). Firms indicated whether they experienced a production, purchasing or supply (i.e. sales/delivery) problem during the first wave of the pandemic. For a complete overview across all industries see Figure A.2 in the Appendix A.1.4.

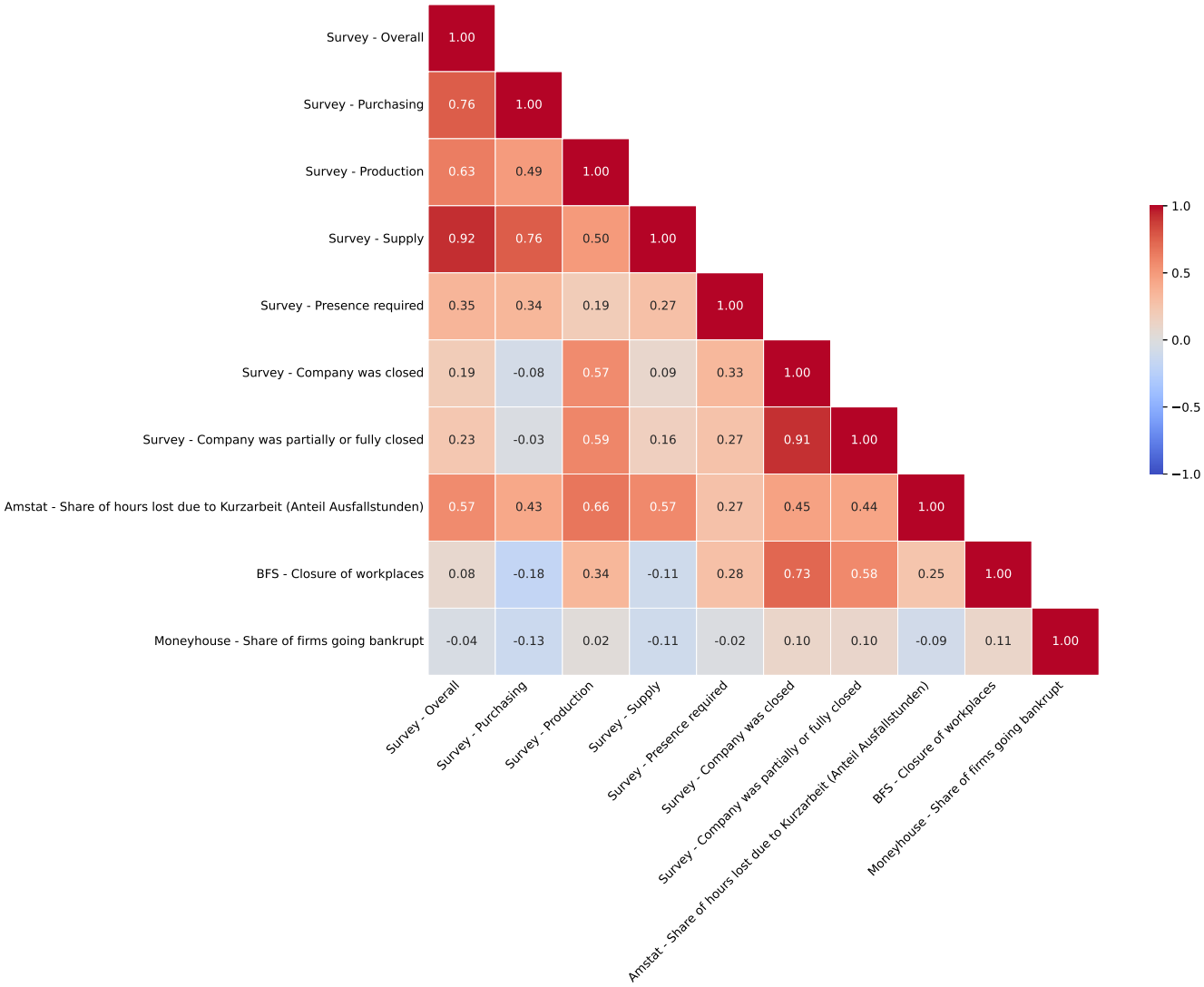


Figure 16: Correlations of survey responses and alternative data sources (across sectors).

4.1.3 Website Data

In the following sections we analyze the fraction of firms affected by the Corona pandemic as expressed on their website broken down by sectors. As a reference point we take the number of firms in a given category that mention Corona on their website, and that have updated their website at least once during the observation period.[15]

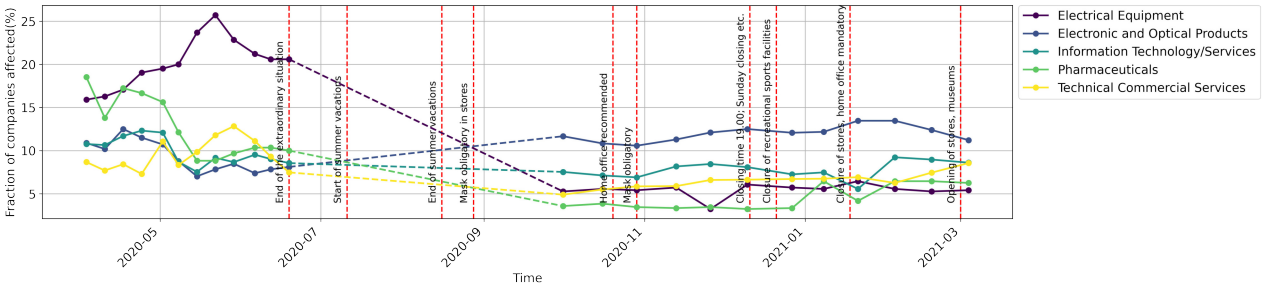
Figure 17 shows the fraction of firms reporting problems with production, demand, financing, supply or travel due to the Corona pandemic broken down by sectors across time (considering only the 5 sectors with the highest fraction of firms mentioning a problem linked to Corona). We find that Electrical Equipment was most affected (in terms of the fraction of firms mentioning a problem linked to Corona) from production problems during the first wave of the pandemic (reaching up to 25% of affected firms), while declining to 5% in the second wave, where Electronic and Optical Products were most affect. This is in line with the results we observed for firms using Kurzarbeit, where Electronic and Optical Products and Electrical Equipment were among the most affected sectors in Switzerland in the first wave of the pandemic (see Figure 12). Demand problems occurred mostly among firms in the Vehicles sector with between 15% and 20% of affected firms in this sector. Financing problems were reported by up to 6% of firms in the Publishing/Media sector in the first wave, and up to 4% of firms in the Printing sector in the second wave. However, the fractions of affected firms declined to around 1% for all sectors at the end of the observation period. Supply problems were reported mostly by firms in the Basic Metals and Electrical Equipment producing sectors in the first wave, while Other Manufacturing was more affected in the second wave. Travel problems affected up to 8% of the firms with similar trends in the first and second wave of the pandemic. The above results seem plausible considering that companies from the manufacturing industries are more likely to struggle with procurement problems than the service sectors, as they are embedded in international value chains here.

Comparing the website based results with the previous analysis (such as short term work), we find significant differences. In particular, the services sectors such as accommodation and restaurants as well as personal sectors used a high degree of short time work, while in the website data these sectors do not show a particular degree of affectedness. These differences could be due to the fact that large companies might be over-represented in the website data if small companies manage their homepage less frequently or extensively. However, the website data can show what kind of problems companies had with a regularly operated website during the Corona pandemic, but this should not be equated with "economic impact" as a whole.

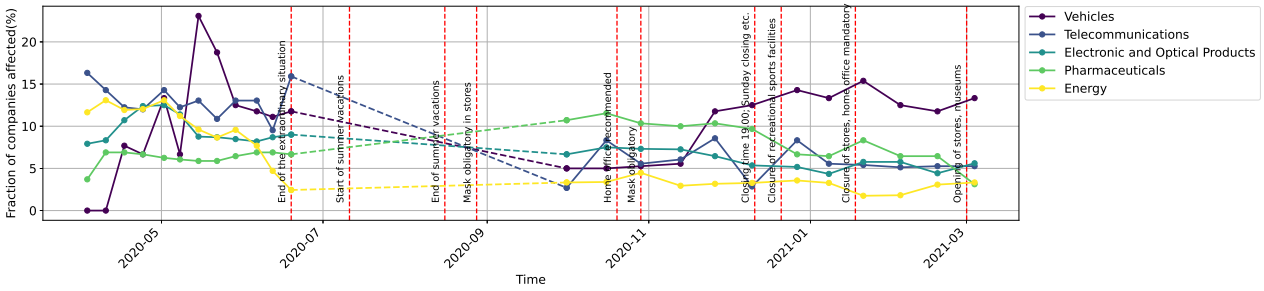
Moreover, looking more closely at specific industries we observe that the banking, finance/insurance and energy sectors expressed frequently negative sentiments related to Covid on their respective company websites. This might be due the fact that these companies report on the problems their customers might have, but that they continue to provide their services despite the difficult circumstances (in terms of credit or energy supply, for example). A simple rule-based (i.e. key word based) text analysis as we have performed it here will not be able to extract and detect such subtleties. More elaborate algorithms and extensive hand coding would be necessary to do this, and we leave this more extensive and complex text analysis for future work.

[15] See also Section 3.1 for a more detailed discussion of the website based data, and Appendix A.2.1 for the sample representativeness.

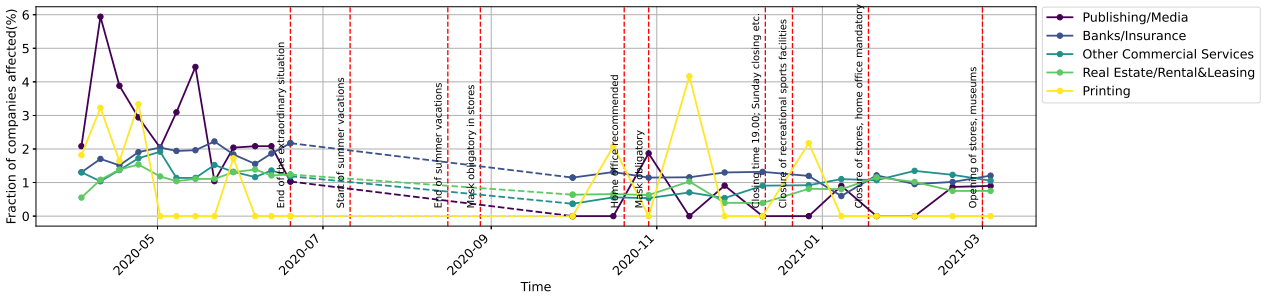
COVID-19 Production Problem



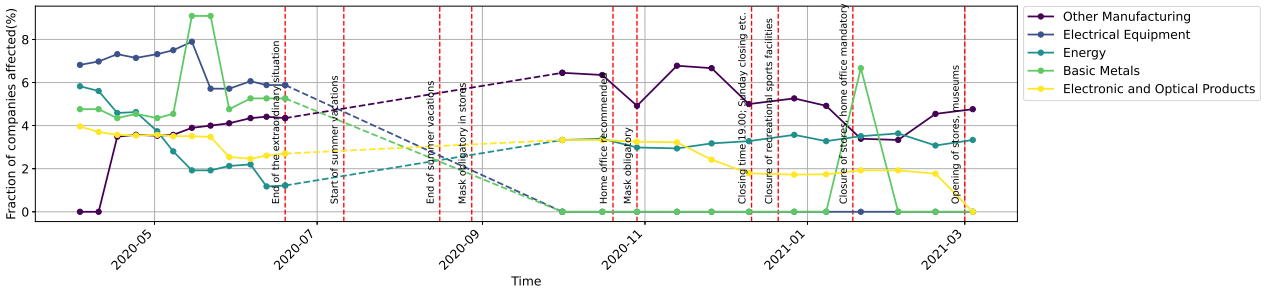
COVID-19 Demand Problem



COVID-19 Financing Problem



COVID-19 Supply Problem



COVID-19 Travel Problem

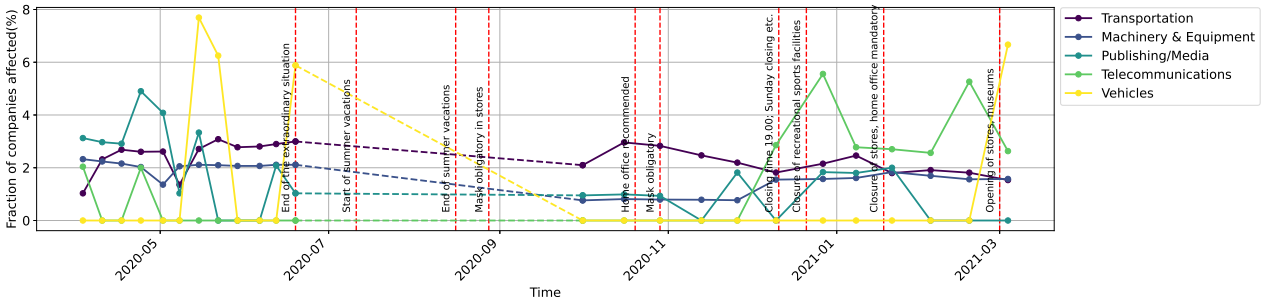


Figure 17: COVID-19 production, demand, financing, supply or travel problem by sector (5 most affected).

4.2 Corona Affectedness by Regions

In the following sections we analyze regional differences in short term work, survey responses as well as the website text analysis.

4.2.1 Short Term Work

Across regions using short term work shown in Figure 18, Ticino, and to a lesser extent the Lake Geneva Region were in the first wave significantly more affected than the rest of Switzerland. In the second wave we do not see any significant regional differences.

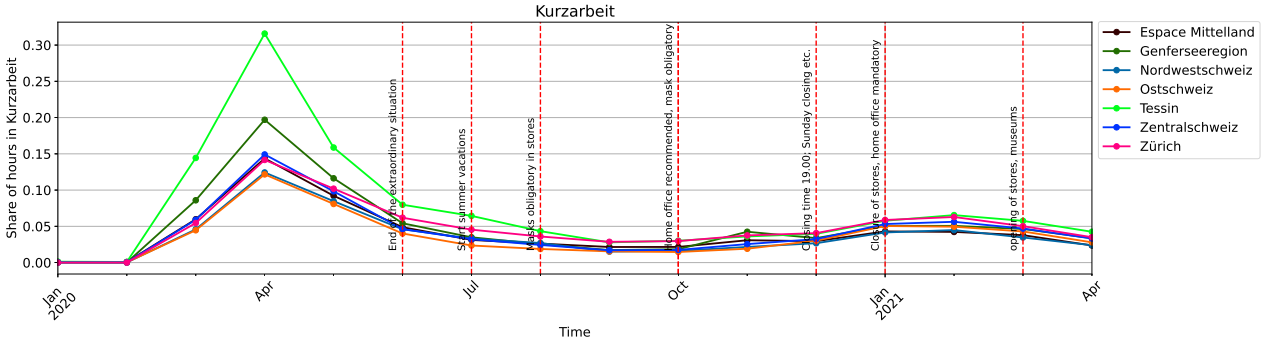


Figure 18: Hours lost due to short term work as a share of total hours worked (BFS data), across regions and time. Vertical lines indicate different policy interventions.

4.2.2 Survey Data

Figure 19 shows the KOF investment survey responses by region. The region of Ticino was most affected by closure. Figure 20 shows the responses of firms in the KOF innovation survey broken down into greater regions in Switzerland. Ticino is the region with the highest overall level of affectedness, and where more than 80% of the respondents report a problem in supply and/or production (70% overall and 30% severely affected). Ticino is also the most affected region from Kurzarbeit during the same time period (see Figure 18). However, other regions are also strongly affected. For example, more that 70% of all respondents in the region of Zurich indicate problems in all three categories (supply, production or purchasing) during the first wave of the Corona pandemic.

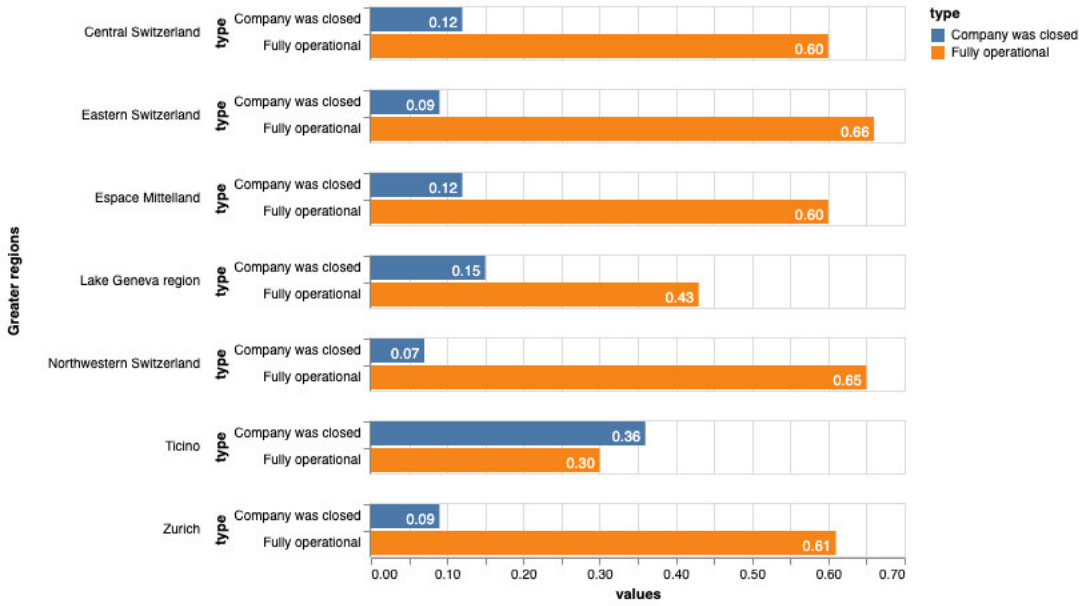


Figure 19: KOF investment survey responses by region (during the first wave of the pandemic).

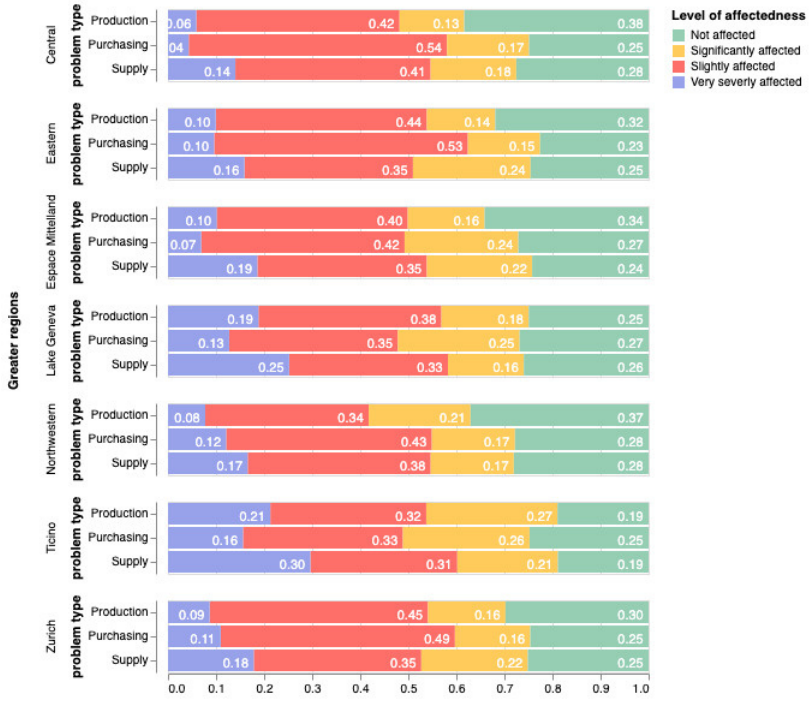


Figure 20: KOF innovation survey responses by region. Firms indicated whether they experienced a production, purchasing or supply (i.e. sales/delivery) problem during the first wave of the pandemic.

4.2.3 Website Data

In this section we analyze regional differences of the Corona affectedness of firms using company websites.

Figure 21 shows spatial maps of COVID-19 production problems across cantons and firm locations from April to June 2020 (during the first wave of infections). Over the course of the first wave of the pandemic we observe that the south-west is affected first and is then followed the by the north-east of Switzerland.

Figure 22 shows spatial maps of COVID-19 production problems across cantons and firm locations from October 2020 to April 2021 (during the second wave of infections). In the second wave of the pandemic we see that the north-west of Switzerland is consistently highly affected, while the east becomes more affected at the end of the observation period.

Figure 23 shows the fraction of firms reporting problems with production, demand, financing, supply or travel due to the Corona pandemic broken down by greater regions across time. Ticino is the least affected region in the second wave of the pandemic in the production, demand and travel problem categories. However, it is among the most affected regions in the first wave of the pandemic among all problem categories. This is consistent with the survey results reported in Section 4.2.2. Moreover, the region of Ticino exhibits the largest fraction of firms reporting financing problems after the second wave of the pandemic.

Comparison across data sources. Figure 24 shows the correlations between topics and data sources across regions. We observe that Corona problem topics are highly correlated among each other and with short term work (Kurzarbeit) as well as the reduction in work place presence, but uncorrelated with bankruptcies. Moreover, they are negatively correlated with the BAG infection statistics. The latter is possibly due to a time lag where the economic impact of the Corona measures comes into effect only when the epidemiological dynamics is already on the decline (at the end of a wave of infections).

Across regions using short term work shown in Figure 18, Ticino, and to a lesser extent the Lake Geneva Region were in the first wave significantly more affected than the rest of Switzerland. In the second wave we do not see any significant regional differences. Since there are no significant differences across regions during the second wave of the pandemic in the short term work data, structural differences (e.g. a larger services sector, composition of firm sizes or the value added contribution of specific sectors like restaurants and catering services) cannot explain the differences across sectors in the first wave of the pandemic (assuming that structural differences did not change significantly over the observation period). Other factors therefore need to be considered such as the proximity to epidemic dynamics in foreign regions or different cultural and social factors across regions.

4.3 Interim Conclusion on the Website Data

To check the consistency of the web-based measures with the survey data we looked at the companies that indicated a production problem in connection with Corona on their website and checked whether these companies also indicated a production problem in the survey. If this is indeed the case, then the web-scraped data can be used to determine the Corona exposure of the companies that use their website as a means of communication.

2020-04 2020-05 2020-06

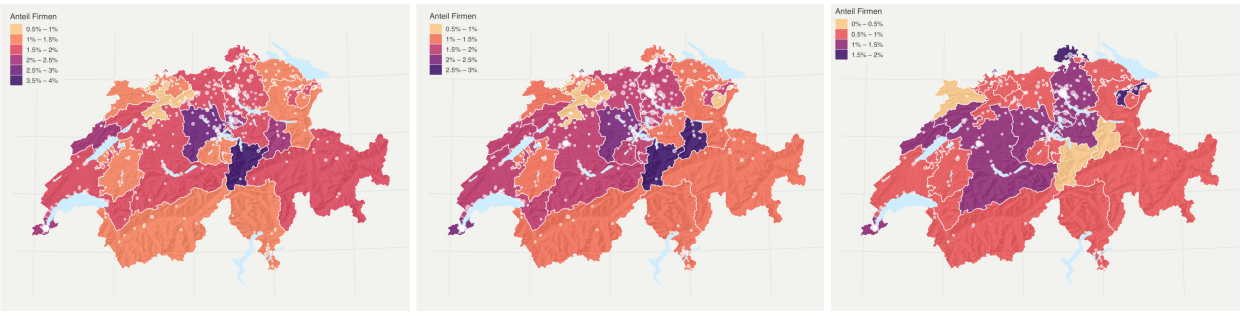
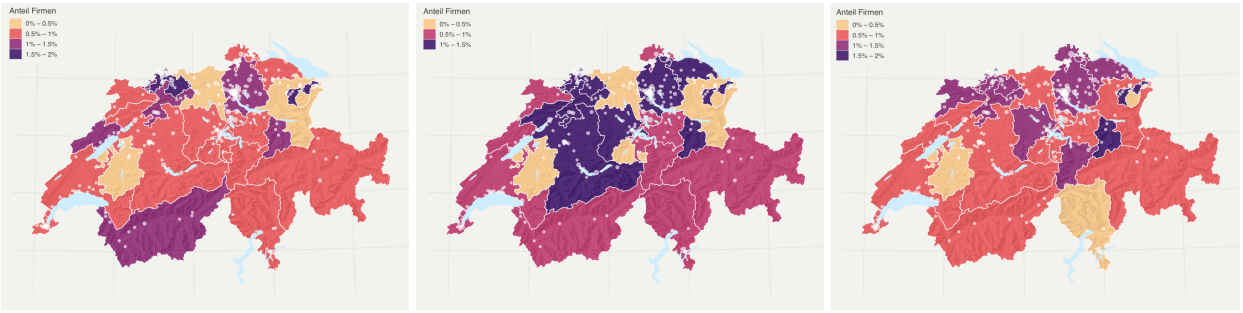


Figure 21: Spatial maps of COVID-19 production shocks (web-based measure) across cantons from 2020-04 to 2020-06 (first wave). Circles indicate densities of firm locations. Darker shades indicate cantons where a higher fraction of firms mentioned a production problem due to Corona.

2020-10 2020-11 2020-12



2021-01 2021-02 2021-03

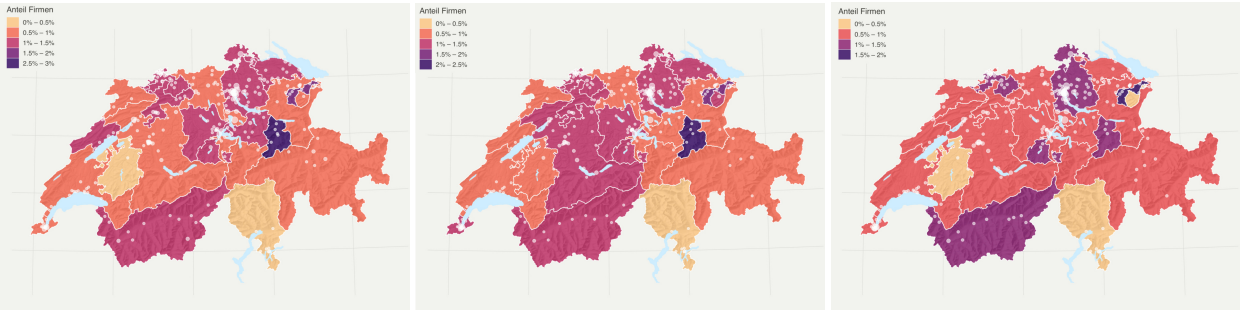
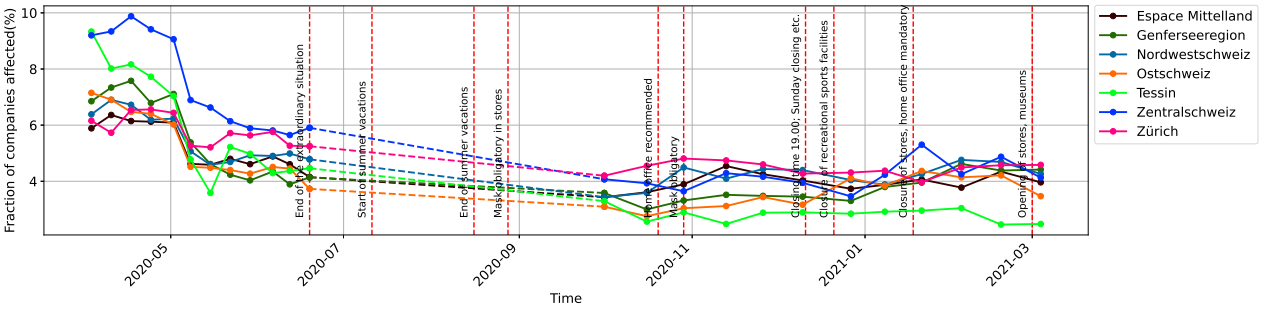
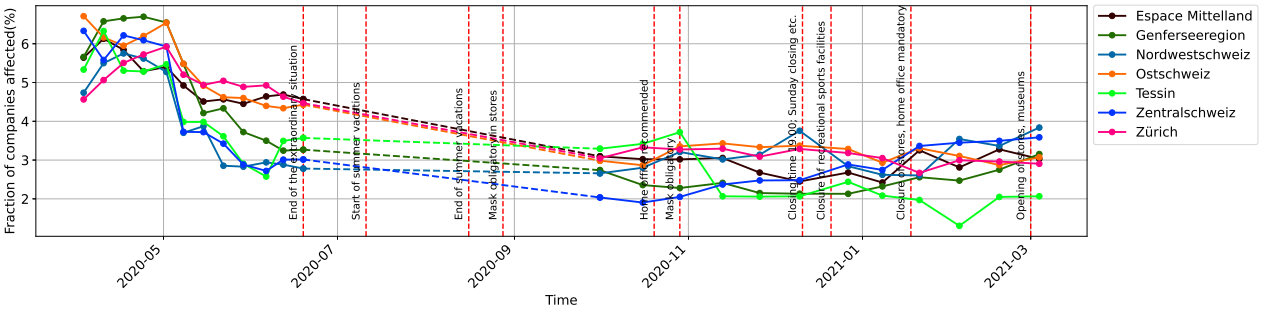


Figure 22: Spatial maps of COVID-19 production shocks (web-based measure) across cantons from 2020-10 to 2021-03 (second wave). Circles indicate densities of firm locations. Darker shades indicate cantons where a higher fraction of firms mentioned a production problem due to Corona.

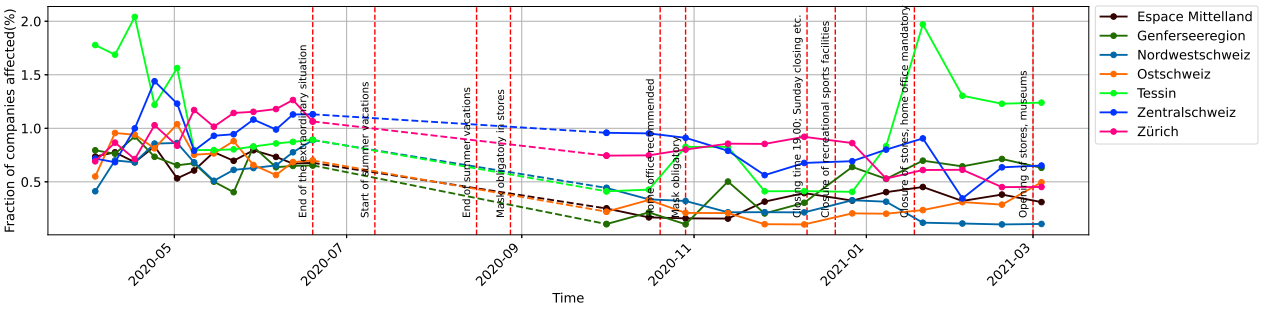
COVID-19 Production Problem



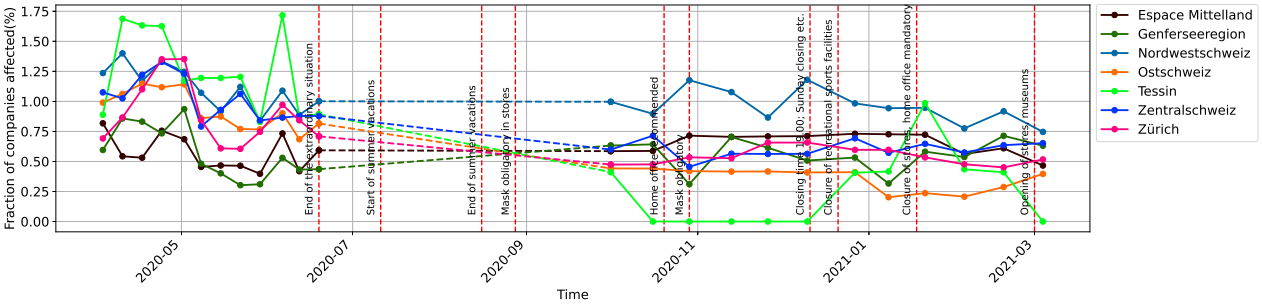
COVID-19 Demand Problem



COVID-19 Financing Problem



COVID-19 Supply Problem



COVID-19 Travel Problem

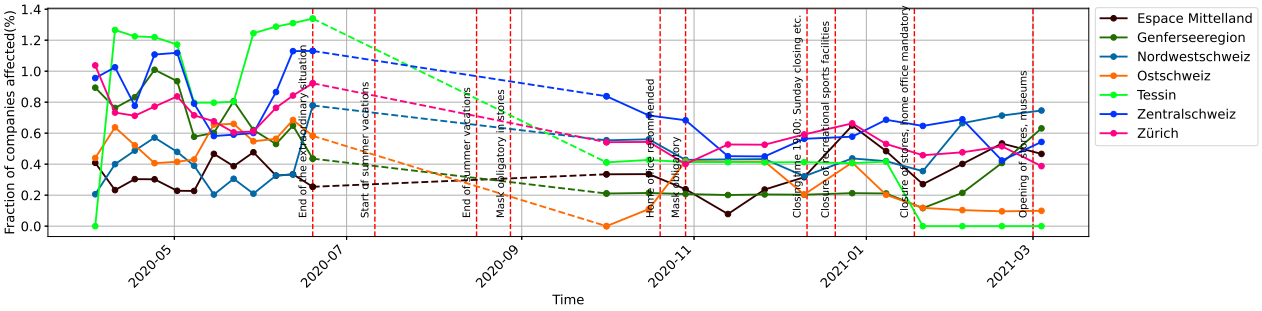


Figure 23: COVID-19 production, demand, financing, supply or travel problem by regions.

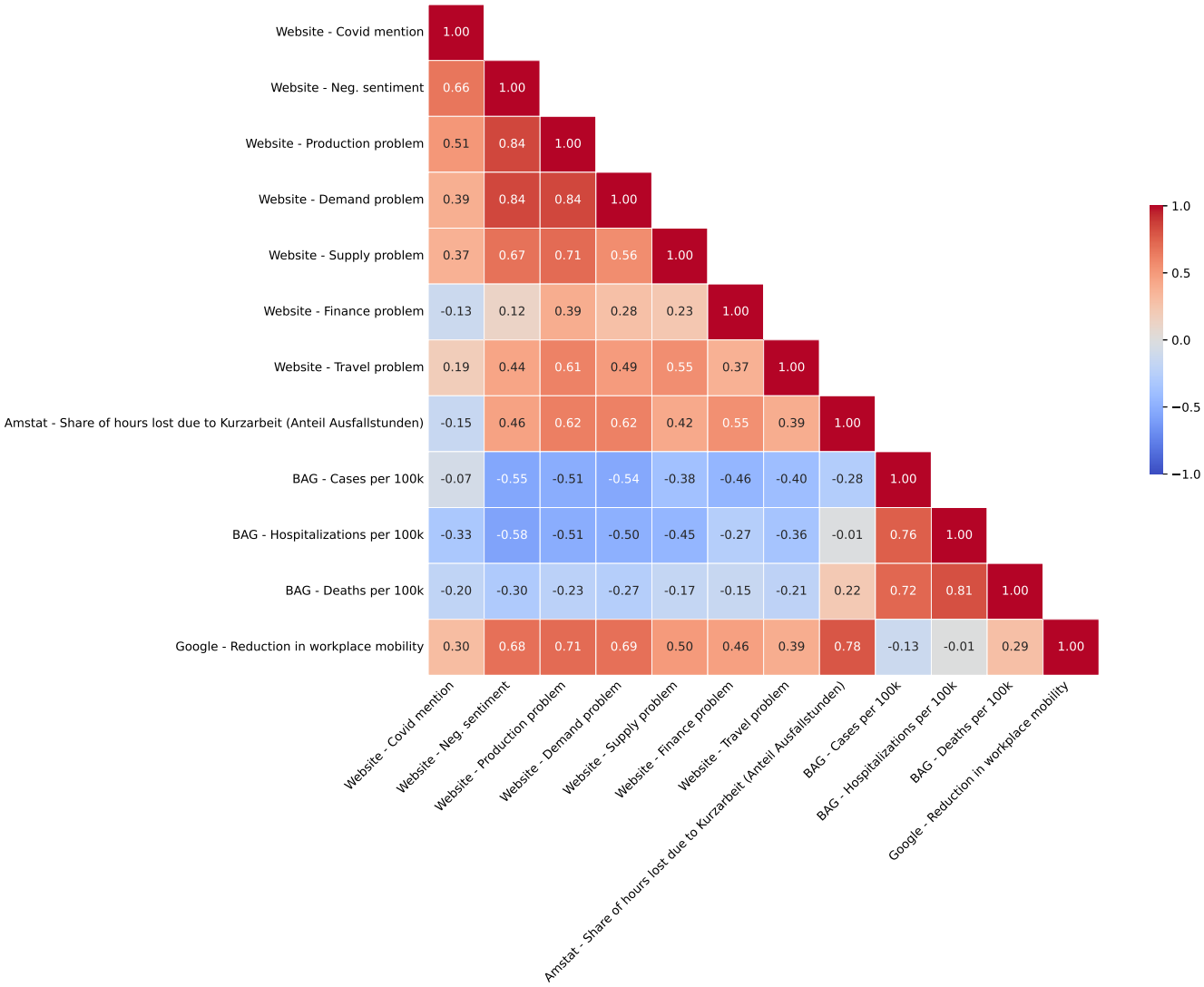


Figure 24: Correlations between topics and data sources across regions.

The comparison of the website data with the short time work data and survey data across industries and regions shows that it is likely that the website data are biased towards firms that update their website more often. Most likely these are rather larger companies. This could also explain why the strongly hit service sectors such as restaurants and accommodation or personal services do no figure among the top sectors mentioning problems on their websites. The website data can therefore not be used to determine which sectors have been most affected and only to a limited extent to which regions are most affected.

However the website data could be used to determine the Corona exposure of companies that use their website as a means of communication. To check the consistency of the web-based measures with the survey data among such firms, we linked the website data to the survey data.

In the industries transportation, accommodation/restaurants, and wholesale trade the web-based and survey measures are more consistent than on average, with a correlation of up to 0.37 between the variables production negative sentiment and survey production shock. Overall, we get higher correlations for larger firms (> 50 FTEs) and firms with more updates (at least 2). There we get an overall correlation of 0.19. All of these are firm-level correlations and the last correlation is based on $n = 244$ observations/firms.

Figure 25 shows the companies (with more than 100 employees) who reported a production problem in connection with Corona on their website and who took part in the survey at the same time (sample size: $n = 402$). The supply, purchasing or production shock variables from the survey are on a scale from 1 (not affected) to 4 (severely affected). Indicators are shown as to whether a company gave a value ≥ 2 or ≥ 3 in the survey. This is compared with all the companies in this data that took part in the survey (other firms). We observe that the companies that indicated a production problem in connection with Corona on their website reported a serious production problem in the survey significantly more often (with concern values ≥ 3). Web-scraping and survey practically always agree with impact values ≥ 2, i.e. whether a company has a production problem or not. These companies also report a supply problem significantly more frequently in the survey (this indicates corona shock spread effects in the production network). In addition, they are significantly more often severely affected by Corona (significantly affected ≥ 3). This means that, for example, over 90% of the companies in question who reported a problem on the website also expressed this in the survey (but not necessarily vice versa). They are also closed more frequently on average and less fully operational. We also see that these companies are typically larger. These results show that we can use web-scraping to measure the Corona impact of a certain type of company that tends to use its website as a means of communication.

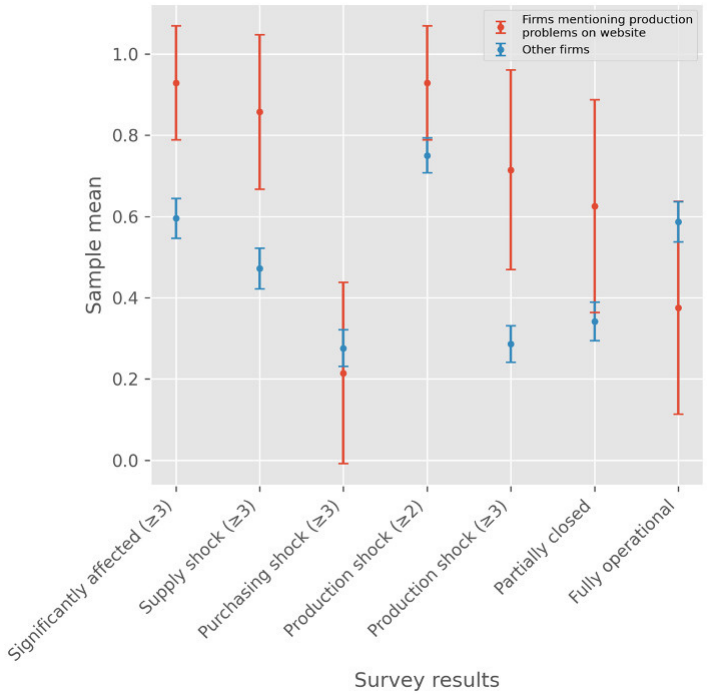


Figure 25: The figure compares the results for companies where we can compare the survey results with the web scraping data and which have more than 100 employees ($n = 402$). The supply, purchasing or production shock variables are on a scale from 1 (not affected) to 4 (severely affected). Indicators are shown as to whether a company gave a value ≥ 2 or ≥ 3 in the survey.

5 Firm Characteristics and Resilience according to Survey Data

In order to find initial indications of which company characteristics increase a company's resilience to the COVID pandemic, we estimate the correlation between the extent to which a company was affected by the pandemic (1st wave) and company characteristics using our survey data. For this purpose, we use two different estimation procedures depending on the dependent variable. One is a fractional logit (categorical variables) and the other is a logit). The fractional logit procedure (see Wooldridge 2002, Papke and Wooldridge 1996) considers the categorical character of the variable and that it is limited between 0 and 5. The logit model is used for binary dependent variables. Alternative estimation procedures, such as a Poisson estimate based on the count-dependent variable or a probit estimate, lead to a very similar result. All estimations show heteroscedasticity robust standard errors.

Dependent variables. We form a general measure of affectedness based on the information provided by the companies on their affectedness along the value chain (purchasing - production - supply), whereby we distinguish between affectedness due to the development of the pandemic at home and abroad in the case of purchasing and supply. We only count those areas in which the company was very strongly affected (value 4 on a 4 point scale). The most affected company thus has a value of 5 and the least affected company has a value of 0.

We also examined the resilience of a company in the individual areas of purchasing, production and supply. Here we built three binary variables informing about whether a company was particularly strong hit in one of these areas.

Main explanatory variables. Given the survey data on firm characteristics, we examine whether a firm's international orientation, as measured by the share of turnover from exports (export share), indicates a greater economic burden from COVID. Indeed, it is likely that international turnover has suffered more than domestic turnover, as the distribution of goods has been strongly affected by COVID-related regulations in the face of travel restrictions and additional border controls.

Companies exposed to price competition tend to be more vulnerable to economic disruption, as they have less organisational slack and lower profit margins to respond immediately to such a crisis. Therefore, we would expect firms that are heavily exposed to price competition to have lower resilience to COVID-induced economic turbulence. We measure the intensity of price competition on a 5-point Likert scale, where 1 indicates low price competition and 5 indicates very high price competition.

On the contrary, we would expect that larger, older, and foreign owned companies would have more leeway and greater financial possibilities to respond to such a crisis and should be less affected economically by a COVID-induced economic shock. We measure company size by the logarithm of the number of employees (full-time equivalents; firm size), age is measured by the logarithm of the number of years since foundation (age), and foreign ownership is a binary variable indicating whether a company is foreign owned or not (foreign owned).

The agility of a company and the detection of response options should be related to the absorptive capacity of a company.The absorptive capacity of a company indicates that it is able to recognize and understand important changes in the environment and to find solutions to problems arising from them (Cohen and Levinthal 1989, 1990). This means that companies with a higher absorptive capacity learn faster and should therefore manage to overcome crisis situations better. First, we measure this capacity with the share of academics in a company and second, whether a company engages in R&D

activities (binary variable). The latter also indicates a company's innovative capacity, i.e. whether it can react as quickly as possible to changing market circumstances by means of new and adapted products and services. Studies for Switzerland show that R&D-active companies are less affected by cyclical fluctuations than non-R&D-active companies under certain conditions (see Spescha and Woerter 2019).

Companies that have made large investments in their hardware and software in recent years and offer an online shop should have come through the crisis better than companies that did not do so or only started to do so during the crisis. We measure hardware and software investment as a share of a company's gross fixed capital formation over the past 3 years (ICT Investment Share) and the availability of an online shop before the COVID pandemic is a binary variable (E-commerce). In addition, we also take into account the company's sales in the previous period in the estimates (Demand). It can be assumed that companies with higher sales per employee are less affected by the crisis than other companies. This also prevents the effect of e-commerce from being influenced by the level of a company's sales and would therefore be misinterpreted.

Control variables. All estimates include control variables for 34 industries (two-digit) covering manufacturing, services and construction, and for a firm's geographic location using cantonal dummies. Thus, we control for unobserved industries and canton-specific factors.

Estimation results. The estimation results of a regression analyses using the Innovation Survey data of the different types of affectedness from the Corona pandemic on various firm characteristics can be seen in Figure 26. The upper left box shows the results for total impact (independent of the value added segment), the upper right box shows the results for purchasing, the lower left box for production and the lower right box shows the results for sales/delivery. The figure shows the correlation coefficients and the 90% confidence interval. The magnitude of the coefficients is indicated by the dots and the confidence interval by the horizontal bars.

It can be seen that a higher export share and high price competition as well as the presence of an online shop (e-commerce) are positively related to a company's overall exposure to the COVID pandemic (Total). The positive correlation with the export share is due to problems in the sales/delivery of goods. This is understandable, especially since the COVID regulations were country-specific and created many uncertainties for exporting companies. In some cases, export channels were even blocked.

The overall positive effect observed for price competition applies irrespective of the segment of the value chain, suggesting that the aspects mentioned above might play a role as they are independent of the type of activity in a company (purchasing, production, etc.).

The significant and positive effect of e-commerce is surprising at first sight. However, a closer look at the results shows that the overall effect is mainly driven by issues related to sales/delivery. This is very plausible, as online shops experienced a strong increase in orders and subsequently the companies had problems delivering the products to the customers. However, the E-commerce effect is also positive (although not significant) concerning the impact on purchasing and production. Nevertheless, this result indicates that, as a consequence of the crisis, the increased demand from the E-commerce channel has also led to production or purchasing problems, for example, because intermediate products, raw materials, or production capacities were not available in sufficient quantities or on time.

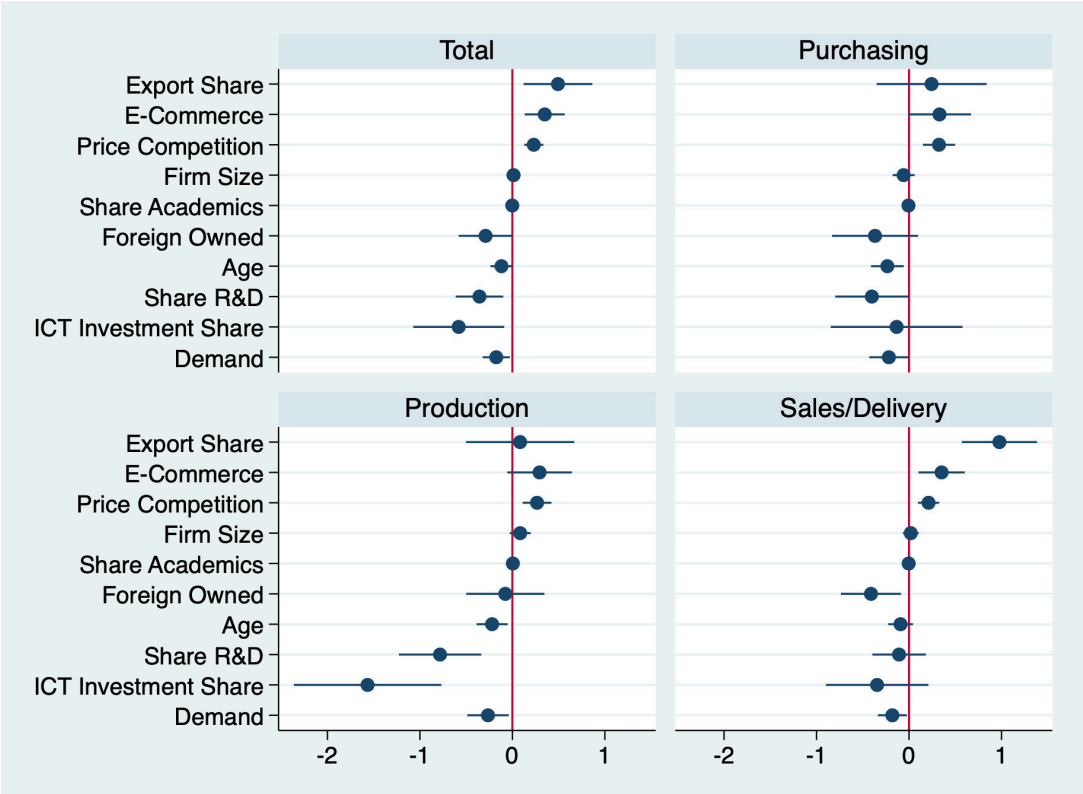


Figure 26: Regression results of firm level characteristics determining Corona affectedness (coefficients are presented).

Since we control for the demand of a company (log of demand per employee), this effect is independent of the magnitude of the demand. Like expected the demand has a negative effect on all types of affectedness. Since we control for a firm's demand, this effect is independent of the size of the demand. As expected, demand has a negative effect on all types of affectedness. In other words, firms with higher demand per employee suffered less from the COVID shock.

While company size and the share of academics show no significant correlation with a company's exposure, we see that foreign-owned companies, older companies, companies with R&D activities and companies with high ICT investments were less affected by the COVID crisis. This also means that the latter factors seem to increase the resilience to such economic shocks. It is particularly interesting to see that ICT investments, the age of a company and R&D activities tend to increase resilience in production, while foreign-owned companies are more resilient to sales/delivery problems. In the latter, it seems that companies can benefit from their international connections.

We also looked at the relationship between a company's ability to let employees work from home. Here we see the expected result that companies that require employees to be present at work were more affected by the first wave of the COVID pandemic (results not presented).[16]

[16]These omitted results can be obtained from the authors upon request.

Comparing website with survey results. In a further robustness test, we regressed the production shock measured by the website information on company and market characteristics including company size, variables related to the company's digitization, foreign ownership, and R&D activities. Similarly, we regressed the production shock based on the survey information (high affectedness: ≥ 3 on a 4-point scale) on the same characteristics. For 323 companies with more than 100 employees both shock measures could be observed. They are significantly correlated. The correlation coefficient for these companies is 0.1542 (highly significant with a p-value of $p = 0.0055$).

As a result, we see the same signs in both estimates for most characteristics, with the exception of firm age and firm size. The magnitude of the coefficients is comparable with the exception of price competition. There are, however, large differences in the precision of the estimation. Significant results are only found for the survey-based dependent variable. This suggests that precise estimates based on web information, requires a larger number of observations.

6 Corona Shock Propagation in Production Networks

To better understand how the Corona shock might propagate across sectors we analyze in the following how short term work (Kurzarbeit) and the production problem identified from the website text analysis correlate across sectors. We illustrate our results together with the sectoral production network. We use information about inter-sectoral linkages from the 2017 Swiss Input-Output table from the National Accounts (available as of September 2021).[17]

Figure 27 shows the fraction of firms with short term work (Kurzarbeit) across sectors together with the input-output linkages connecting sectors. High levels of affectedness occur between sectors with strong input-output relationships like Machinery and Equipment and Electronic and Optical Products.

Figure 28 shows the web-based production problem across sectors and the input-output sectoral linkages. Negative sentiments jointly occur between connected sectors like Pharmaceuticals and Chemicals or Electrical Equipment and Basic Metals.

6.1 Estimation of Shock Propagation Effects

Econometric model. In the following we quantify the shock propagation effect from one sector to another. We distinguish between downstream (customers/demand) and upstream (supplier) shock propagation effects using input-output sectoral linkages. For this purpose we consider a panel spatial autoregressive (SAR) model (Lee and Yu, 2010). It is formally specified as follows:

$$\mathbf{y}_t = \rho \mathbf{W} \mathbf{y}_t + \mathbf{X}_t \boldsymbol{\beta} + \boldsymbol{\delta} + \boldsymbol{\varepsilon}_t \tag{2}$$

where $\mathbf{y}_t = (y_{1t}, y_{2t}, \ldots, y_{nt})$ is an $n \times 1$ vector of observations for the dependent variable (different Covid shock measures) for time period t with n number of sectors; $\mathbf{X}_t$ is a matrix of time- and sector-varying regressors (policy interventions or productivity), $\boldsymbol{\delta}$ is an $n \times 1$ vector of sector fixed effects,[18] and $\boldsymbol{\varepsilon}_t$ is a vector of disturbances and is independent and identically distributed (i.i.d.) across sectors and time with variance σ. As time- and sector-varying regressors in $\mathbf{X}_t$ we include:

[17] https://www.bfs.admin.ch/bfs/en/home/statistics/national-economy/input-output.html

[18] Note that we can include also a time fixed effect (capturing any epidemiological dynamics or time varying changes on international markets) without changing the results. The estimation results can be obtained upon request.

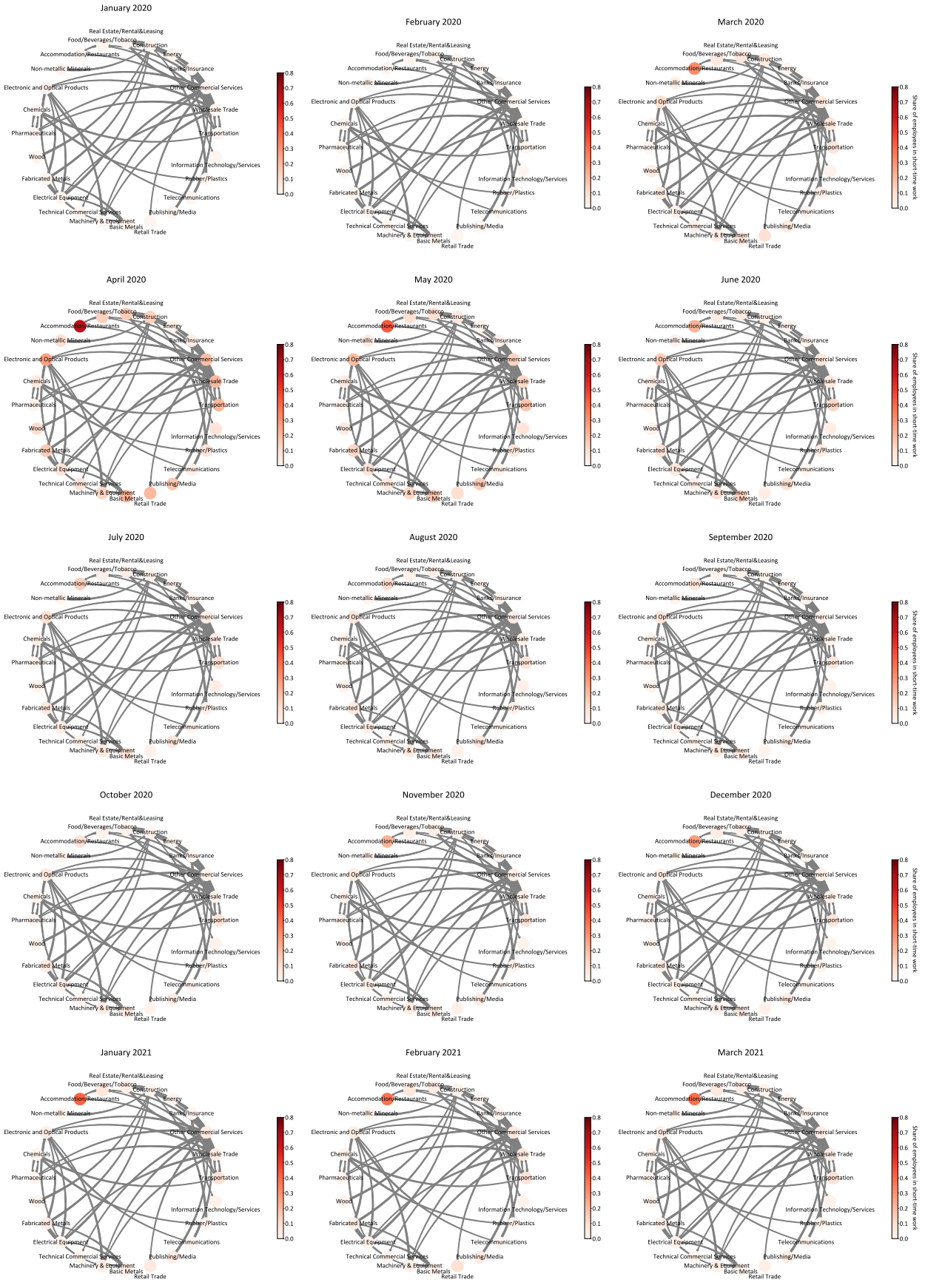


Figure 27: Illustration of fraction of firms using short term work (Kurzarbeit) across sectors and the input-output sectoral linkages.

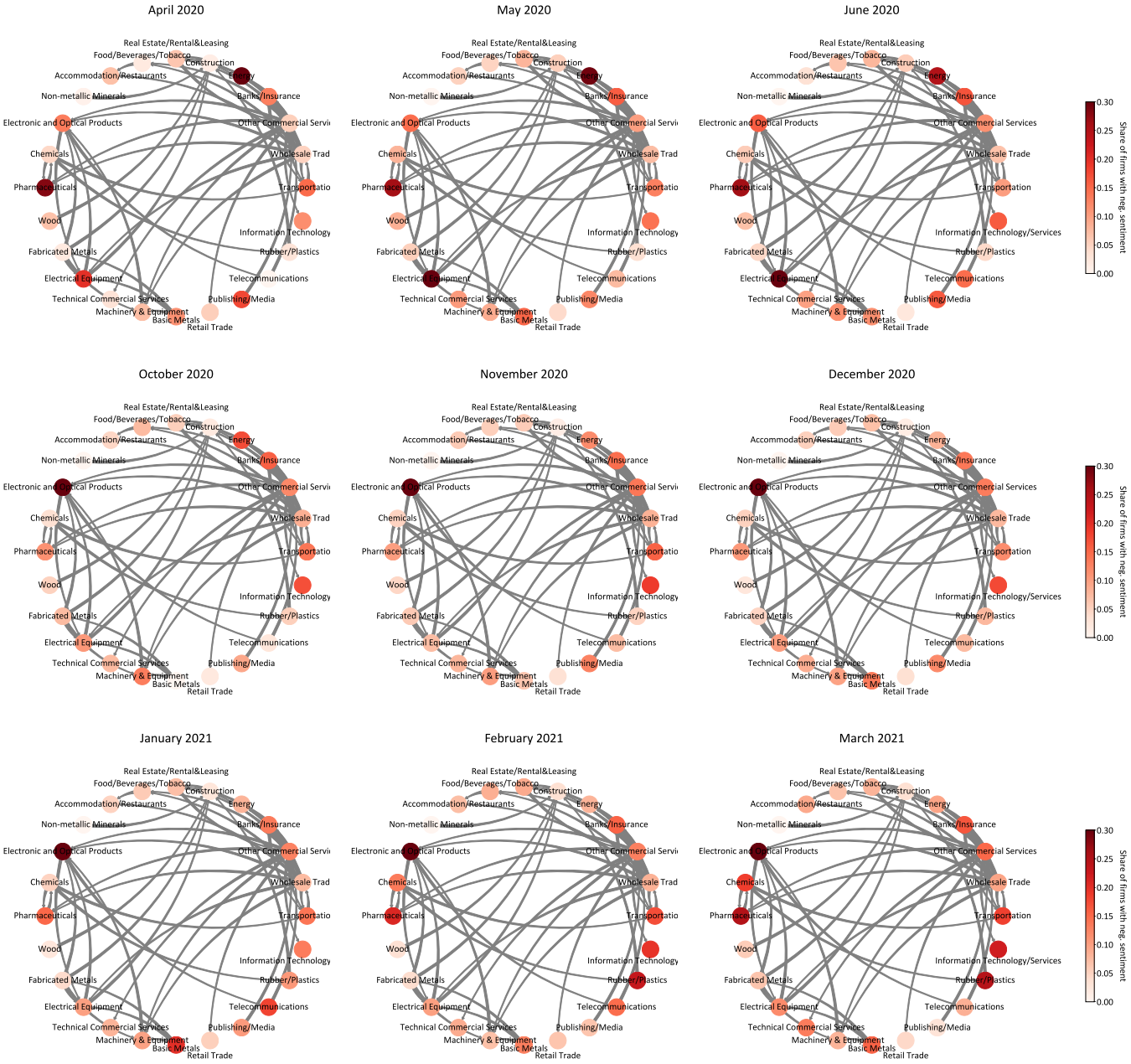


Figure 28: Illustration of the web-based production problems across sectors and the input-output sectoral linkages.

- Workplace closure from the Oxford Covid-19 Government Policy Response Tracker[19] (time-varying) interacted with the difficulty of home office from the KOF Investment survey (industry-varying);
- As a robustness check, we also include labor productivity (calculated as value added divided by full time equivalents). Unfortunately, up-to-date data on value added is only provided by the BFS for relatively coarse industry groups. The data is available at quarterly intervals.

Furthermore, $\mathbf{W}$ is the spatial weighting matrix, from the symmetric input-output table (illustrated in Figures 27 and 28, respectively). Its elements, w_{ij}, are the input provided from sector i to sector j. We normalize this figure by dividing it by the sum of all inputs the sector provides, plus exports and household consumption - in other words, the total output of the sector. The elements w_{ij} are then output shares provided to each domestic sector. To get upstream effects, we simply transpose the weighting matrix and estimate the same equation (2) with $\mathbf{W}^\top$ instead of $\mathbf{W}$.

Estimation results. In the following we consider three alternative dependent variables ($\mathbf{y}_t$):

- Short term work (Kurzarbeit)[20]
- Website productivity Covid shock
- Website negative sentiment

We further distinguish between upstream and downstream Covid shock propagation effects. The downstream and upstream results can be seen in Tables 1 and 2, respectively. In both tables we observe that the policy intervention (work place closure interacted with the difficulty of home office) has a positive and significant effect on the Corona affectedness of an industry. Moreover, the shock propagation effect (ρ) for all measures considered is positive and significant. We also note that the shock propagation results for the share of firms in short term work, the share of hours in short term work as well as the production problem (measured from the company websites) are very similar.

For the interpretation of the estimated shock propagation parameter ρ consider a hypothetical economy in which sector i supplies to only one sector j. Then a percentage point increase in the shock experienced by sector j leads to an increase in the shock experienced by sector i by 1.791 percentage points in the case of the share of firms in short term work. In a general input-output economy, the increase refers to the weighted average of all the shocks by the downstream sectors (weighted by $\mathbf{W}$).

[19] https://www.bsg.ox.ac.uk/research/research-projects/covid-19-government-response-tracker

[20] Either measured by the fraction of firms using short term work in a sector or the fraction of hours (FTE) in short term work in a sector.

Table 1: Downstream shock propagation effect.

	Short Term Work (Kurzarbeit)		Websites	
	Share of Firms (1)	Share of Hours (2)	Prod. Neg. Sentiment (3)	Negative Sentiment (4)
Regressors (β)				
Constant	0.070***	0.043***	0.008***	0.019***
	(0.002)	(0.001)	(0.000)	(0.001)
Workpl. closing × pres. required	0.050***	0.027***	0.003*	0.009**
	(0.006)	(0.004)	(0.002)	(0.004)
Network (ρ)				
Share of firms in Kurzarbeit	1.791***			
	(0.110)			
Share of hours in Kurzarbeit		1.776***		
		(0.156)		
Production negative sentiment			1.739***	
			(0.318)	
Negative sentiment				0.892***
				(0.176)
Observations	496	496	279	279

Standard errors in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 2: Upstream shock propagation effect.

	Short Term Work (Kurzarbeit)		Websites	
	Share of Firms (1)	Share of Hours (2)	Prod. Neg. Sentiment (3)	Negative Sentiment (4)
Regressors (β)				
Constant	0.073***	0.044***	0.008***	0.018***
	(0.002)	(0.001)	(0.000)	(0.001)
Workpl. closing × pres. required	0.041***	0.025***	0.002	0.005
	(0.007)	(0.004)	(0.002)	(0.004)
Network (ρ)				
Share of firms in Kurzarbeit	1.651***			
	(0.117)			
Share of hours in Kurzarbeit		1.503***		
		(0.158)		
Production negative sentiment			1.934***	
			(0.330)	
Negative sentiment				2.139***
				(0.245)
Observations	496	496	279	279

Standard errors in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

6.2 Robustness Analysis

In the following sections we analyze the robustness of our shock propagation analysis by including labor productivity as an explanatory variable and by considering a sample split for the first and second wave of the pandemic.

Robustness: Labor productivity. To check the robustness of our shock propagation estimates we perform a robustness analysis where we include labor productivity as an additional explanatory variable. The downstream and upstream results can be seen in Tables 3 and 4, respectively. We find that the shock propagation effects are qualitatively similar to the baseline regression (Tables 1 and 2, respectively) but their magnitude changes due to the different sectoral composition using the BFS industries. Moreover, we observe that productivity has a mitigating effect on the Covid shock measured by Kurzarbeit.

Table 3: Downstream shock propagation effects for BFS industries.

	Short Term Work (Kurzarbeit)	Websites	
	Share of Hours (1)	Prod. Neg. Sentiment (2)	Negative Sentiment (3)
Regressors (β)			
Constant	0.049***	0.046***	0.074***
	(0.002)	(0.003)	(0.005)
Productivity	-13.326***	0.321	3.576
	(1.575)	(2.287)	(3.915)
Workpl. closing × pres. required	0.046***	0.002	0.017
	(0.007)	(0.015)	(0.024)
Network (ρ)			
Share of hours in Kurzarbeit	1.071***		
	(0.392)		
Production negative sentiment		0.805	
		(0.754)	
Negative sentiment			1.045*
			(0.563)
Observations	208	117	117

Standard errors in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 4: Upstream shock propagation effects for BFS industries.

	Short Term Work (Kurzarbeit)	Websites	
	Share of Hours (1)	Prod. Neg. Sentiment (2)	Negative Sentiment (3)
Regressors (β)			
Constant	0.050***	0.045***	0.069***
	(0.003)	(0.003)	(0.005)
Productivity	-13.858***	0.709	4.101
	(1.566)	(2.248)	(3.462)
Workpl. closing × pres. required	0.049***	-0.002	0.011
	(0.007)	(0.015)	(0.023)
Network (ρ)			
Share of hours in Kurzarbeit	0.597**		
	(0.291)		
Production negative sentiment		2.204**	
		(1.061)	
Negative sentiment			3.309***
			(0.742)
Observations	208	117	117

Standard errors in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Robustness: First and second waves. In Appendix A.2.3 we show the results of the shock propagation regression analysis in Equation (2) for the first and second waves of the pandemic separately (with a sample split before and September 2020). We find that the propagation effects are similar to the full sample analysis, but that the estimates are larger in the second wave than in the first, both, for the downstream and the upstream effects. This could indicate that the economic shock diffuses with some delay through the economy, so that during the second wave the shock propagation effects were larger than during the first wave. Moreover, we see that the proxy for policy intervention (work place closure interacted with the difficulty of home office) has a positive and significant effect on the Corona affectedness of an industry only in the first wave of the pandemic. This indicates that the possibility of working from home no longer played a role in the second wave, since companies were better able to adapt to it, or that the policy measures in this regard were less stringent. In any case, this could suggest that this particular measure taken to address the health problems have not further harmed the economy.

6.3 Sectoral Rankings

In the following we provide a ranking of sectors according to how strongly they are affected by shock propagation effects. Tables 5 and 6 show the rankings for upstream or downstream shock propagation effects, respectively, for short term work (Kurzarbeit). The most highly affected downstream sector is Repair/Installation. The shock propagation effect in column (1) in Table 5 is larger than the idiosyncratic shock in column (2) of the table for that sector. The highest ranked sector for the upstream shock propagation effect in Table 6 is Rubber/Plastics. Similarly, the idiosyncratic shock for this sector is smaller than the upstream shock propagation effect. Column (3) in both tables shows that the highest ranked sectors are not necessarily the ones that are also the largest in the economy.

It is interesting to note that economically important sectors such as Wholesale Trade, Pharmaceuticals and Banking/Insurance not only exhibit low industry-specific shock levels but are also less affected by upstream and downstream shocks. They appear to be relatively insulated from the input-output relationship and are robust to the effects of shock propagation. The Accommodation/Restaurant sector also appears to be a rather "isolated" case. It is strongly affected by the idiosyncratic shock to the industry, but less strongly affected by shocks to other industries. This suggests that policies targeting other industries have little impact on this sector.

Strongly affected by upstream shocks are Rubber/Plastics, Wood, Other Manufacturing, Real Estate/Rental&Leasing, and Textiles and Clothing. The sector-specific shock is particularly large for Textiles and Clothing and Other Manufacturing, making these sectors particularly vulnerable to the crisis. However, their contribution to the overall economic impact is relatively small due to their relatively small economic size.

Repair/Installation, Technical Commercial Services, Vehicles, Information Technology/Services, and Electrical Equipment are strongly affected by downstream shocks. Repair/Installation also has a high industry-specific shock level, making it a fairly exposed industry. However, its economic size is rather small. This is hardly true for the other "downstream" affected sectors, making them more important for the overall economic impact of the crisis.

It is also interesting to note that the sectors that are strongly exposed to upstream shocks are - with the exception of Estate/Rental&Leasing - hardly exposed to downstream shocks.

Figure 29 shows the correlation of downstream and upstream shocks from Tables 5 and 6, re-

Table 5: Downstream average shock propagation effects for the share of hours in Kurzarbeit (WK08 groups, see table 17).

Industry	Downstream Shock[a] (1)	Industry Shock[b] (2)	Relative Industry Size[c] (3)	Rank[d]
Repair/Installation	0.236	0.050	0.006	1
Technical Commercial Services	0.084	0.021	0.032	2
Vehicles	0.079	0.033	0.021	3
Information Technology/Services	0.068	0.027	0.041	4
Electrical Equipment	0.057	0.030	0.021	5
Printing	0.055	0.076	0.003	6
Real Estate/Rental&Leasing	0.051	0.043	0.053	7
Transportation	0.038	0.090	0.067	8
Other Commercial Services	0.035	0.053	0.008	9
Non-metallic Minerals	0.034	0.018	0.007	10
Basic Metals	0.031	0.070	0.014	11
Telecommunications	0.030	0.005	0.020	12
Energy	0.028	0.002	0.035	13
Paper	0.028	0.024	0.004	14
Fabricated Metals	0.027	0.053	0.021	15
Accommodation/Restaurants	0.025	0.251	0.025	16
Machinery & Equipment	0.025	0.053	0.033	17
Chemicals	0.023	0.019	0.034	18
Wood	0.023	0.019	0.008	19
Textiles/Clothing	0.021	0.119	0.012	20
Water/Environment	0.021	0.015	0.008	21
Food/Beverages/Tobacco	0.019	0.047	0.037	22
Retail Trade	0.015	0.048	0.020	23
Publishing/Media	0.015	0.059	0.007	24
Banks/Insurance	0.014	0.009	0.089	25
Construction	0.013	0.025	0.062	26
Pharmaceuticals	0.013	0.003	0.097	27
Other Manufacturing	0.013	0.066	0.028	28
Electronic and Optical Products	0.012	0.080	0.056	29
Rubber/Plastics	0.007	0.026	0.010	30
Wholesale Trade	0.002	0.049	0.123	31

[a] The downstream shock is measured by $\rho\mathbf{Wy}$ from Equation (2).

[b] The industry shock is measured by the dependent variable $\mathbf{y}$ in Equation (2).

[c] The relative industry size is measured by the total use at basic prices of an industry divided by the sum of total use across all industries.

[d] The ranking is based on column (1) in the table.

Table 6: Upstream average shock propagation effects for the share of hours in Kurzarbeit (WK08 groups, see table 17).

Industry	Upstream Shock[a] (1)	Industry Shock[b] (2)	Relative Industry Size[c] (3)	Rank[d]
Rubber/Plastics	0.057	0.026	0.010	1
Wood	0.026	0.019	0.008	2
Other Manufacturing	0.020	0.066	0.028	3
Real Estate/Rental&Leasing	0.019	0.043	0.053	4
Textiles/Clothing	0.019	0.119	0.012	5
Construction	0.018	0.025	0.062	6
Publishing/Media	0.017	0.059	0.007	7
Retail Trade	0.015	0.048	0.020	8
Chemicals	0.015	0.019	0.034	9
Repair/Installation	0.014	0.050	0.006	10
Non-metallic Minerals	0.014	0.018	0.007	11
Fabricated Metals	0.014	0.053	0.021	12
Vehicles	0.013	0.033	0.021	13
Other Commercial Services	0.013	0.053	0.008	14
Energy	0.013	0.002	0.035	15
Information Technology/Services	0.012	0.027	0.041	16
Telecommunications	0.012	0.005	0.020	17
Electrical Equipment	0.011	0.030	0.021	18
Wholesale Trade	0.011	0.049	0.123	19
Electronic and Optical Products	0.011	0.080	0.056	20
Printing	0.010	0.076	0.003	21
Water/Environment	0.010	0.015	0.008	22
Machinery & Equipment	0.010	0.053	0.033	23
Accommodation/Restaurants	0.009	0.251	0.025	24
Pharmaceuticals	0.008	0.003	0.097	25
Transportation	0.007	0.090	0.067	26
Technical Commercial Services	0.007	0.021	0.032	27
Paper	0.006	0.024	0.004	28
Basic Metals	0.006	0.070	0.014	29
Food/Beverages/Tobacco	0.005	0.047	0.037	30
Banks/Insurance	0.004	0.009	0.089	31

[a] The downstream shock is measured by $\rho\mathbf{Wy}$ from Equation (2).

[b] The industry shock is measured by the dependent variable $\mathbf{y}$ in Equation (2).

[c] The relative industry size is measured by the total use at basic prices of an industry divided by the total total use across all industries.

[d] The ranking is based on column (1) in the table.

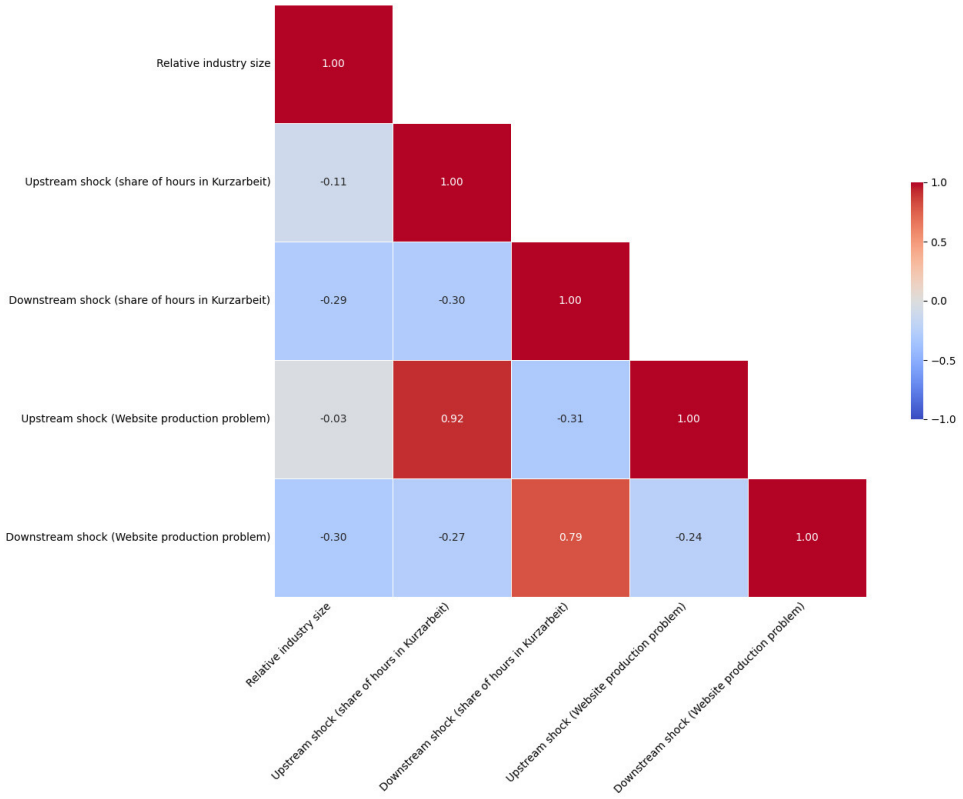


Figure 29: Correlation of downstream shocks, upstream shocks and relative industry size (share of total use).

spectively, together with the relative industry size (measured by the total use of an industry divided by the sum of total use across all industries). We observe that the upstream production shock using the website measure is highly correlated with the upstream shock of firms in short term work (Kurzarbeit). Almost as highly positively correlated are the downstream production shock and the downstream shock of firms in short term work. This illustrates that the website shock measure captures similar shock propagation effects as the short term work. Moreover, industry size is negatively correlated with all shock propagation measures. This indicates that larger industries suffer less from the propagation of shocks from other industries (both, downstream and upstream).

7 Conclusion

Our analysis indicates that firms were more affected in the first than the second wave of the Corona pandemic in Switzerland, and large firms could adjust better to the shock in the second wave. Moreover, during the first wave between 8% (large) and 13% (small) of the companies have been closed at least some times. The Corona problem mentions are highly correlated with short term work (Kurzarbeit) and reduction in work place presence (Google mobility), but uncorrelated with bankruptcies and negatively correlated with infections (possibly due to a time lag). According to the KOF innovation survey sectors which mention problems with Covid the most are often manufacturing sectors that have limited home office possibilities, and that produce input for downstream sectors that are directly affected by the pandemic (e.g. Food/Beverages and Accommodation/Restaurants). Analyzing differences across regions we find that while Ticino was highly affected in the first wave, West and East/Central Switzerland were more affected in the second wave.

Our resilience analysis shows that companies that were heavily affected by the first wave of the pandemic face strong price competition, are export intensive and have difficulties delivering the goods ordered online. In contrast, R&D-active companies, foreign-owned companies and companies with good digital infrastructure are less affected.

Moreover, our sectoral network analysis shows that there exist positive and significant shock propagation effects across sectors (irrespective of the particular measure used). Industries that are strongly connected in the network (such as some manufacturing sectors) can exhibit propagation effects that far exceed their direct exposure from the pandemic. In contrast, relatively isolated sectors in the production network such as Accommodation/Restaurants are strongly affected by the idiosyncratic shock to that industry, but less strongly affected by shocks to other industries. This suggests that policies targeting other industries have little impact on this sector.

By comparing survey responses with Corona problem mentions on company websites we found that websites can be used as a valuable information sources for firms that use their website as a communication tool, which are typically larger companies. When controlling for firm size in the regressions of firm characteristics on Corona affectedness and when quantifying shock propagation effects across sectors, we find that web-based measures yield similar results as we obtain them from alternative measures such as short term work. This further corroborates the observation that company websites can be used as a valuable source of information for economic performance and behavior at the firm level.

There are however, caveats to the proposed method. Larger firms tend to have larger websites and tend to update them more frequently. Hence, larger firms tend to be more dominant in a web-scraped sample. Moreover, we find that for specific industries such as banking/finance and the energy sector companies expressed frequently negative sentiments related to Covid on their websites. This might be due the fact that companies in these sectors report on the problems of their customers, but that they continue to provide their services despite the difficult circumstances (in terms of credit or energy supply, for example). A simple rule-based (i.e. key word based) text analysis as we have performed it in this study will not be able to extract and detect such subtleties. This implies that websites as we have analyzed them here can be used as a valuable source of information to detect and analyze economic shocks, but that differences across sectors need to be taken into account before any general conclusions can be drawn.

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Appendix

A Data Appendix

A.1 Survey Data Appendix

A.1.1 KOF Investment Survey Sample Representativeness

Table 7: KOF investment survey response rates.

	Net Sample				Net Response				Response Rate			
Sectors	Small	Midium-sized	Large	Total	Small	Midium-sized	Large	Total	Small	Midium-sized	Large	Total
Food/Beverages/Tobacco	278	160	17	460	53	48	11	113	19.1	30	64.7	24.6
Textiles/Clothing	73	50	3	129	21	11	2	34	28.8	22	66.7	26.4
Wood	137	35	1	175	36	11	0	48	26.3	31.4	0	27.4
Paper	22	26	1	49	5	7	0	12	22.7	26.9	0	24.5
Printing	66	39	1	109	18	17	0	37	27.3	43.6	0	33.9
Chemicals	122	71	11	206	36	19	4	61	29.5	26.8	36.4	29.6
Pharmaceuticals	67	48	8	125	15	12	5	33	22.4	25	62.5	26.4
Rubber/Plastics	78	71	3	153	15	21	3	39	19.2	29.6	100	25.5
Non-metallic Minerals	86	51	5	144	19	21	3	43	22.1	41.2	60	29.9
Basic Metals	38	36	3	78	3	15	3	21	7.9	41.7	100	26.9
Fabricated Metals	447	190	7	650	110	53	3	169	24.6	27.9	42.9	26
Machinery & Equipment	270	242	18	535	71	78	5	155	26.3	32.2	27.8	29
Electrical Equipment	125	62	12	201	25	14	2	43	20	22.6	16.7	21.4
Electronic and Optical Products	181	128	12	324	31	35	2	68	17.1	27.3	16.7	21
Repair/Installation	70	13	2	85	11	2	1	14	15.7	15.4	50	16.5
Medical Instruments	62	22	3	87	19	6	2	27	30.6	27.3	66.7	31
Watches/Clocks	134	70	8	215	18	14	3	35	13.4	20	37.5	16.3
Vehicles	45	22	6	75	10	7	2	20	22.2	31.8	33.3	26.7
Other Manufacturing	69	44	1	116	9	18	0	28	13	40.9	0	24.1
Energy	88	53	8	152	38	19	6	65	43.2	35.8	75	42.8
Water/Environment	68	35	1	105	19	8	0	27	27.9	22.9	0	25.7
Construction	501	448	157	1118	98	123	52	275	19.6	27.5	33.1	24.6
Wholesale Trade	376	427	86	899	89	117	26	235	23.7	27.4	30.2	26.1
Retail Trade	592	190	72	873	109	39	26	179	18.4	20.5	36.1	20.5
Accommodation/Restaurants	249	215	48	528	45	44	14	109	18.1	20.5	29.2	20.6
Transportation	261	209	74	556	62	52	31	150	23.8	24.9	41.9	27
Telecommunications	70	45	12	132	12	5	6	23	17.1	11.1	50	17.4
Publishing/Media	32	29	13	78	8	9	1	18	25	31	7.7	23.1
Information Technology/Services	116	97	36	260	34	27	7	76	29.3	27.8	19.4	29.2
Banks/Insurance	277	192	96	576	88	63	39	192	31.8	32.8	40.6	33.3
Real Estate/Rental&Leasing	252	156	29	455	72	37	5	119	28.6	23.7	17.2	26.2
Technical Commercial Services and R&D	182	150	34	373	62	52	11	129	34.1	34.7	32.4	34.6
Other Commercial Services	391	287	74	759	130	47	16	193	33.2	16.4	21.6	25.4
Personal Services	129	51	4	199	42	10	1	60	32.6	19.6	25	30.2
Total	5954	3964	866	10979	1433	1061	292	2850	24.07	26.77	33.72	26

A.1.2 KOF Innovation Survey Sample Representativeness

Table 8: KOF innovation survey sample description by industry (net sample).

		Small	Medium-sized	Large	**Total**
Sector	NOGA 2008	Number of Companies			
MANUFACTURING		1'467	1'163	225	2'855
Food/Beverages/Tobacco	10, 11, 12	181	179	17	377
Textiles/Clothing	13, 14, 15	21	25	4	50
Wood	16	37	39	16	92
Paper	17	14	13	5	32
Printing	18	18	20	23	61
Chemicals	19, 20	102	31	7	140
Pharmaceuticals	21	112	14	1	127
Rubber/Plastics	22	33	47	23	103
Non-metallic Minerals	23	39	41	6	86
Basic Metals	24	18	19	9	46
Fabricated Metals	25	177	187	32	396
Machinery & Equipment	28	173	200	21	394
Electrical Equipment	27	75	55	7	137
Electronic and Optical Products	261, 262, 263, 264, 2651, 266, 267, 268	142	97	7	246
Repair/Installation	33	18	25	3	46
Medical Instruments	325	29	25	9	63
Watches/Clocks	2652	130	49	3	182
Vehicles	29, 30	37	15	2	54
Other Manufacturing	31, 321, 322, 323, 324, 329	20	21	12	53
Energy	35	67	27	10	104
Water/Environment	36, 37, 38 , 39	24	34	8	66
CONSTRUCTION	41, 42, 43	264	247	54	565
SERVICES		1'453	1'051	307	2'811
Wholesale Trade	45, 46	176	177	77	430
Retail Trade	47, 95	353	82	4	439
Accommodation/Restaurants	55, 56	105	94	52	251
Transportation	49, 50, 51, 52, 79	194	154	4	352
Telecommunications	53, 61	27	16	2	45
Publishing/Media	58, 59, 60	17	15	3	35
Information Technology/Services	62, 63	50	53	33	136
Banks/Insurance	64, 65, 66	183	96	14	293
Real Estate/Rental&Leasing	68, 77, 81	88	78	10	176
Technical Commercial Services and R&D	71, 72	58	61	55	174
Other Commercial Services	69, 70, 73, 74, 78, 80, 82	196	218	40	454
Personal Services	96	6	7	13	26
Total		3'184	2'461	586	6'231

Table 9: KOF innovation survey sample description by industry (net response).

		Small	Medium-sized	Large	**Total**
Sector	NOGA 2008	Number of Companies			
MANUFACTURING		428	324	74	826
Food/Beverages/Tobacco	10, 11, 12	40	41	7	88
Textiles/Clothing	13, 14, 15	4	7	3	14
Wood	16	12	21	7	40
Paper	17	4	3	3	10
Printing	18	3	5	5	13
Chemicals	19, 20	41	9	1	51
Pharmaceuticals	21	20	1	1	22
Rubber/Plastics	22	13	12	8	33
Non-metallic Minerals	23	17	13	2	32
Basic Metals	24	4	9	5	18
Fabricated Metals	25	58	61	14	133
Machinery & Equipment	28	62	52	6	120
Electrical Equipment	27	26	13	0	39
Electronic and Optical Products	261, 262, 263, 264, 2651, 266, 267, 268	30	21	1	52
Repair/Installation	33	8	7	0	15
Medical Instruments	325	12	6	1	19
Watches/Clocks	2652	20	7	0	27
Vehicles	29, 30	11	6	2	19
Other Manufacturing	31, 321, 322, 323, 324, 329	6	10	6	22
Energy	35	30	9	2	41
Water/Environment	36, 37, 38 , 39	7	11	0	18
CONSTRUCTION	41, 42, 43	76	90	17	183
SERVICES		411	321	72	804
Wholesale Trade	45, 46	55	71	16	142
Retail Trade	47, 95	82	24	1	107
Accommodation/Restaurants	55, 56	30	27	14	71
Transportation	49, 50, 51, 52, 79	58	55	1	114
Telecommunications	53, 61	6	1	2	9
Publishing/Media	58, 59, 60	4	5	1	10
Information Technology/Services	62, 63	21	17	10	48
Banks/Insurance	64, 65, 66	53	26	3	82
Real Estate/Rental&Leasing	68, 77, 81	25	15	2	42
Technical Commercial Services and R&D	71, 72	22	31	13	66
Other Commercial Services	69, 70, 73, 74, 78, 80, 82	53	48	6	107
Personal Services	96	2	1	3	6
Total		915	735	163	1813

Table 10: KOF innovation survey sample description by industry (response rate).

		Small	Medium-sized	Large	Total
Sector	NOGA 2008	Number of Companies			
MANUFACTURING		29.2	27.9	32.9	28.9
Food/Beverages/Tobacco	10, 11, 12	22.1	22.9	41.2	23.3
Textiles/Clothing	13, 14, 15	19.0	28.0	75.0	28.0
Wood	16	32.4	53.8	43.8	43.5
Paper	17	28.6	23.1	60.0	31.3
Printing	18	16.7	25.0	21.7	21.3
Chemicals	19, 20	40.2	29.0	14.3	36.4
Pharmaceuticals	21	17.9	7.1	100.0	17.3
Rubber/Plastics	22	39.4	25.5	34.8	32.0
Non-metallic Minerals	23	43.6	31.7	33.3	37.2
Basic Metals	24	22.2	47.4	55.6	39.1
Fabricated Metals	25	32.8	32.6	43.8	33.6
Machinery & Equipment	28	35.8	26.0	28.6	30.5
Electrical Equipment	27	34.7	23.6	0.0	28.5
Electronic and Optical Products	261, 262, 263, 264, 2651, 266, 267, 268	21.1	21.6	14.3	21.1
Repair/Installation	33	44.4	28.0	0.0	32.6
Medical Instruments	325	41.4	24.0	11.1	30.2
Watches/Clocks	2652	15.4	14.3	0.0	14.8
Vehicles	29, 30	29.7	40.0	100.0	35.2
Other Manufacturing	31, 321, 322, 323, 324, 329	30.0	47.6	50.0	41.5
Energy	35	44.8	33.3	20.0	39.4
Water/Environment	36, 37, 38 , 39	29.2	32.4	0.0	27.3
CONSTRUCTION	41, 42, 43	28.8	36.4	31.5	32.4
SERVICES		28.3	30.5	23.5	28.6
Wholesale Trade	45, 46	31.3	40.1	20.8	33.0
Retail Trade	47, 95	23.2	29.3	25.0	24.4
Accommodation/Restaurants	55, 56	28.6	28.7	26.9	28.3
Transportation	49, 50, 51, 52, 79	29.9	35.7	25.0	32.4
Telecommunications	53, 61	22.2	6.3	100.0	20.0
Publishing/Media	58, 59, 60	23.5	33.3	33.3	28.6
Information Technology/Services	62, 63	42.0	32.1	30.3	35.3
Banks/Insurance	64, 65, 66	29.0	27.1	21.4	28.0
Real Estate/Rental&Leasing	68, 77, 81	28.4	19.2	20.0	23.9
Technical Commercial Services and R&D	71, 72	37.9	50.8	23.6	37.9
Other Commercial Services	69, 70, 73, 74, 78, 80, 82	27.0	22.0	15.0	23.6
Personal Services	96	33.3	14.3	23.1	23.1
Total		28.7	29.9	27.8	29.1

A.1.3 KOF Investment Survey Responses by Industry

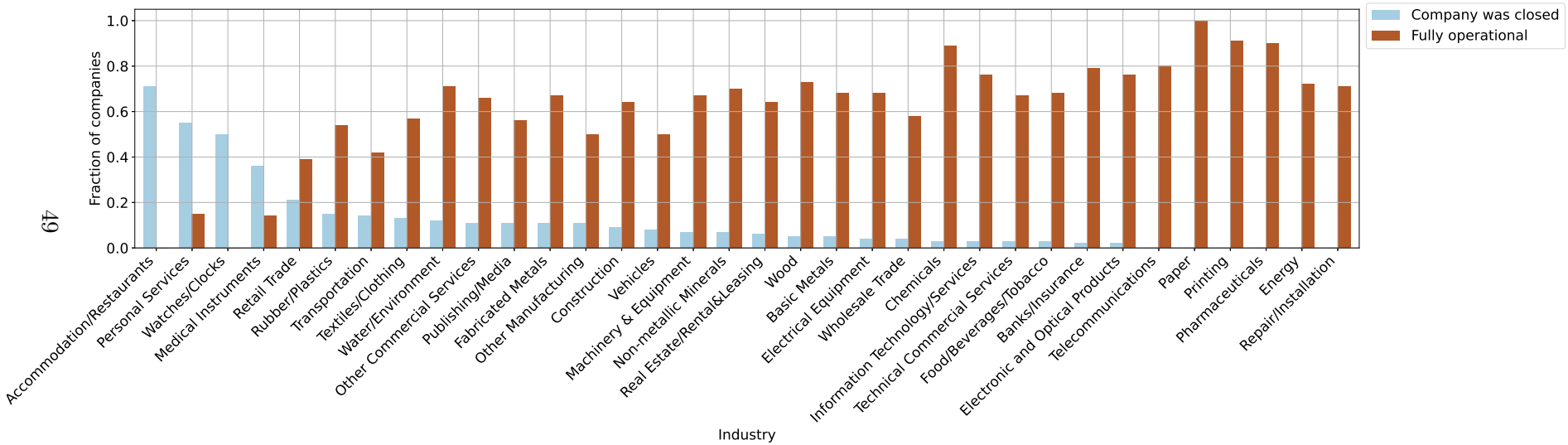

Figure A.1: KOF investment survey responses by industry.

A.1.4 KOF Innovation Survey Responses by Industry

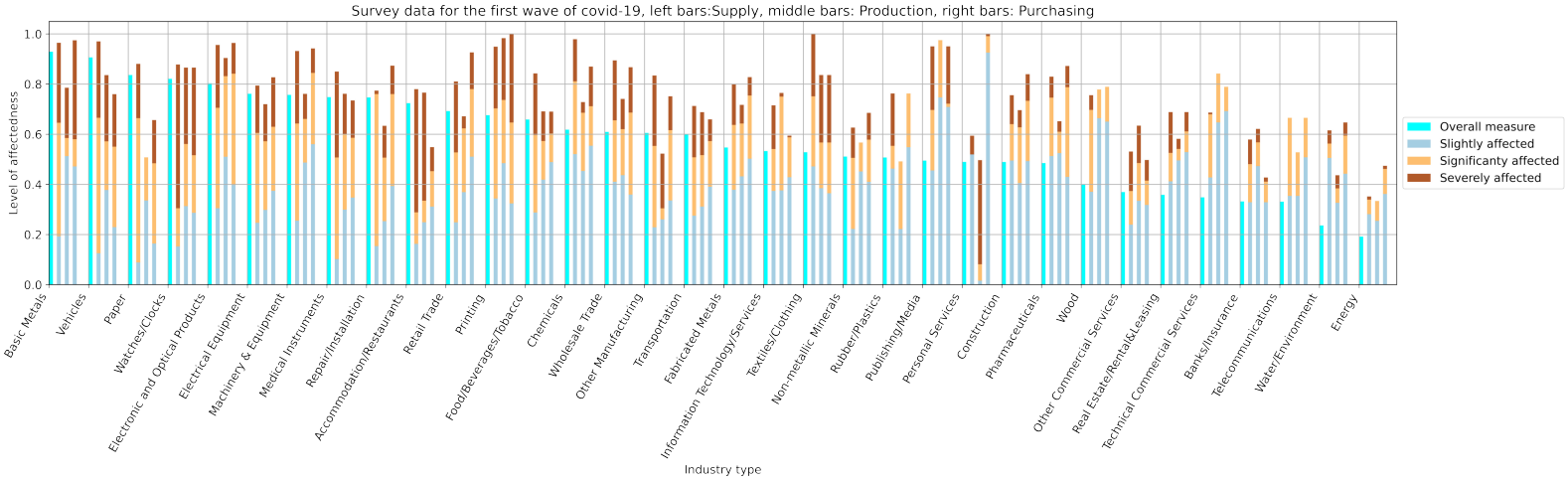

Figure A.2: KOF innovation survey responses by industry.

A.2 Website Data Appendix

A.2.1 Web Sample Representativeness

Table 11: Web-scraped sample representativeness by industry.

Industry (WK08)	Number of active firms (STATENT)	Number of firms scraped 03.04.2020–04.03.2021	Share active firms (STATENT)	Share of scraped firms 03.04.2020–04.03.2021
Food/Beverages/Tobacco	14502	572	3.04%	1.44%
Textiles/Clothing	44058	296	9.23%	0.75%
Wood	8223	646	1.72%	1.63%
Paper	179	70	0.04%	0.18%
Printing	2125	332	0.45%	0.84%
Chemicals	705	226	0.15%	0.57%
Pharmaceuticals	567	105	0.12%	0.26%
Rubber/Plastics	753	262	0.16%	0.66%
Non-metallic Minerals	1302	201	0.27%	0.51%
Basic Metals	1120	114	0.23%	0.29%
Fabricated Metals	7363	1149	1.54%	2.90%
Machinery & Equipment	2023	722	0.42%	1.82%
Electrical Equipment	810	238	0.17%	0.60%
Electronic and Optical Products	1974	617	0.41%	1.56%
Repair/Installation	2569	237	0.54%	0.60%
Vehicles	445	92	0.09%	0.23%
Other Manufacturing	4796	448	1.00%	1.13%
Energy	783	253	0.16%	0.64%
Water/Environment	1460	216	0.31%	0.54%
Construction	48134	3301	10.08%	8.33%
Wholesale Trade	39594	4175	8.29%	10.53%
Retail Trade	37304	2386	7.81%	6.02%
Accommodation/Restaurants	28514	1907	5.97%	4.81%
Transportation	15251	1146	3.19%	2.89%
Telecommunications	948	145	0.20%	0.37%
Publishing/Media	4775	462	1.00%	1.17%
Information Technology/Services	17560	1979	3.68%	4.99%
Banks/Insurance	16183	2468	3.39%	6.22%
Real Estate/Rental & Leasing	33073	3809	6.93%	9.61%
Technical Commercial Services	26425	2178	5.54%	5.49%
Other Commercial Services	75987	3919	15.92%	9.88%
Personal Services	37873	256	7.93%	0.65%

Table 12: Web-scraped sample representativeness by size and regions.

Regions

	Number of active firms (STATENT)	Number of firms scraped 03.04.2020–04.03.2021	Share active firms (STATENT)	Share of scraped firms 03.04.2020–04.03.2021
Lake of Geneva Region	109901	5954	19.75%	15.40%
Espace Mittelland	105874	7188	19.02%	18.59%
North West Switzerland	67621	4982	12.15%	12.88%
Zurich	103357	7712	18.57%	19.94%
East Switzerland	73941	5773	13.29%	14.93%
Central Switzerland	61196	5074	11.00%	13.12%
Ticino	34684	1991	6.23%	5.15%
NaN/Unknown		975		
Total	556574	38674		

Size Classes (FTEs)

	Number of active firms (STATENT)	Number of firms scraped 03.04.2020–04.03.2021	Share active firms (STATENT)	Share of scraped firms 03.04.2020–04.03.2021
1-4	496902	20558	81.98%	55.88%
5-49	99387	11805	16.40%	32.09%
50-249	8321	3655	1.37%	9.93%
>249	1480	772	0.24%	2.10%
Total	606090	36790		

A.2.2 Firms with Frequently Updated Websites

We were able to access around 250 million websites (domains) of companies worldwide provided by "Dataprovider.com", a private company specialized in business website data. The dataset also contains around 200 website related variables. Based on a keyword search, we identified via the Dataprovider search interface those Swiss companies (Swiss domain) who published information about Corona. Furthermore we use the geographic information on the domains (hostnames), information on the economic sector and the so-called *heartbeat* indicator developed by Dataprovider. This indicator represents an activity value, showing the frequency and scope of the changes (updates) that the owner of the website has made. The indicator ranges from none to extreme. We selected those websites for our analysis that had a heartbeat value of high, very high or extreme. In total, we were able to use 295,260 companies (hostnames) on the Dataprovider interface with 56,205 companies operating a website that has a high, very high, or extreme heartbeat. Further, we identified the co-occurrence of COVID-19 (and its synonyms) together with a negative valence keyword for 8830 firms in April 2021.[24]

Figure A.3 shows the fraction of COVID-19 problem mentioning firms across different size classes considering only firms with frequently updated websites (high, very high, or extreme heartbeat) in April 2021. Small firms were most severely affected.

Figure A.4 shows the fraction of COVID-19 problem mentioning firms across different sectors considering only firms with frequently updated websites (high, very high, or extreme heartbeat). Services, transportation and publishing were the most severely affected sectors.

The above results are largely consistent with the findings in the main text.

[24] As negative valence keywords we used: cautiousness, cautious, volatility, volatile, problem, pressures, setback, tough, difficulty, difficult, hurdle, obstacle, challenge, concern, uncertainty, decline, decrease, cancel, reduce, fall, decelerate, cancellation, inconvenience, interruption, lower, down, disrupt, impact, shift, affect, change, maintain, stop, delay, postpone, close, constrain, adjust, slow, shut down, cost, late, interrupted, and cancel.

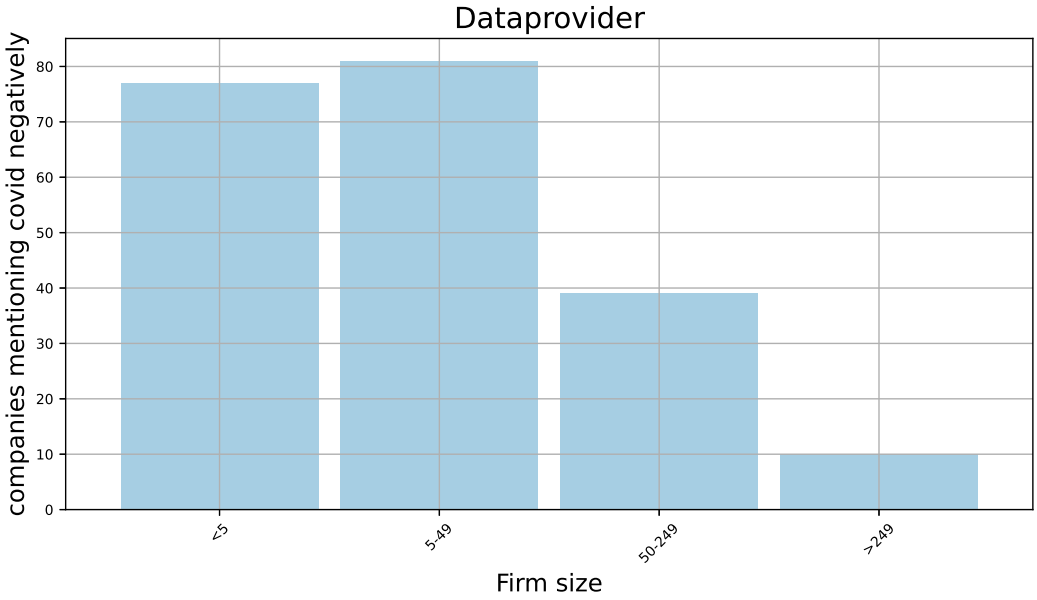

Figure A.3: Fraction of COVID-19 problem mentioning firms across different size classes considering only firms with frequently updated websites (source: Dataprovider.com).

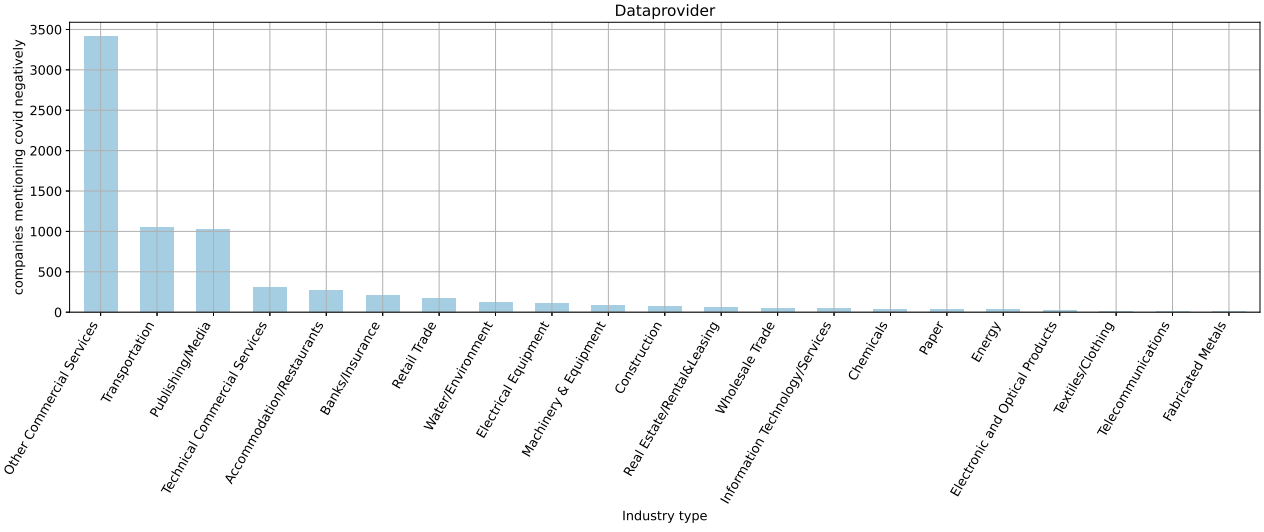

Figure A.4: Fraction of COVID-19 problem mentioning firms across different sectors considering only firms with frequently updated websites (source: Dataprovider.com).

A.2.3 Network Shock Propagation: Sample split for first and second waves

In the following we provide a shock propagation regression analysis for the first and second waves of the pandemic separately (sample split).

First wave: Before September 2020. Tables 13 and 14 show the regression results for the downstream and upstream shock propagation results for the observations in the first wave only (before September 2020).

Table 13: Downstream shock propagation effect, first wave.

	Short Term Work (Kurzarbeit)		Websites	
	Share of Firms (1)	Share of Hours (2)	Prod. Neg. Sentiment (3)	Negative Sentiment (4)
Regressors (β)				
Constant	0.077***	0.047***	0.008***	0.013***
	(0.004)	(0.002)	(0.001)	(0.001)
Workpl. closing × pres. required	0.102***	0.057***	0.008***	0.018***
	(0.009)	(0.006)	(0.002)	(0.003)
Network (ρ)				
Share of firms in Kurzarbeit	1.174***			
	(0.151)			
Share of hours in Kurzarbeit		0.926***		
		(0.216)		
Production negative sentiment			0.034	
			(0.745)	
Negative sentiment				0.301
				(0.346)
Observations	248	248	93	93

Standard errors in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 14: Upstream shock propagation effect, first wave.

	Short Term Work (Kurzarbeit)		Websites	
	Share of Firms	Share of Hours	Prod. Neg. Sentiment	Negative Sentiment
	(1)	(2)	(3)	(4)
Regressors (β)				
Constant	0.084***	0.049***	0.008***	0.013***
	(0.004)	(0.002)	(0.001)	(0.001)
Workpl. closing × pres. required	0.107***	0.065***	0.009***	0.015***
	(0.012)	(0.007)	(0.003)	(0.004)
Network (ρ)				
Share of firms in Kurzarbeit	0.784***			
	(0.187)			
Share of hours in Kurzarbeit		0.313		
		(0.246)		
Production negative sentiment			-0.655	
			(1.068)	
Negative sentiment				0.865
				(0.653)
Observations	248	248	93	93

Standard errors in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Second wave: From September 2020. Tables 15 and 16 show the regression results for the downstream and upstream shock propagation results for the observations in the first wave only (from September 2020).

Table 15: Downstream shock propagation effect, second wave.

	Short Term Work (Kurzarbeit)		Websites	
	Share of Firms (1)	Share of Hours (2)	Prod. Neg. Sentiment (3)	Negative Sentiment (4)
Regressors (β)				
Constant	0.037***	0.026***	0.004***	0.011***
	(0.002)	(0.001)	(0.000)	(0.001)
Workpl. closing × pres. required	-0.002	-0.006	-0.002	-0.006
	(0.016)	(0.011)	(0.002)	(0.005)
Network (ρ)				
Share of firms in Kurzarbeit	2.691***			
	(0.377)			
Share of hours in Kurzarbeit		2.680***		
		(0.453)		
Production negative sentiment			1.099**	
			(0.431)	
Negative sentiment				1.781***
				(0.403)
Observations	248	248	186	186

Standard errors in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 16: Upstream shock propagation effect, second wave.

	Short Term Work (Kurzarbeit)		Websites	
	Share of Firms (1)	Share of Hours (2)	Prod. Neg. Sentiment (3)	Negative Sentiment (4)
Regressors (β)				
Constant	0.039***	0.027***	0.004***	0.012***
	(0.002)	(0.001)	(0.000)	(0.001)
Workpl. closing × pres. required	-0.000	-0.004	-0.002	-0.005
	(0.017)	(0.012)	(0.002)	(0.005)
Network (ρ)				
Share of firms in Kurzarbeit	1.385***			
	(0.326)			
Share of hours in Kurzarbeit		1.475***		
		(0.423)		
Production negative sentiment			2.010***	
			(0.542)	
Negative sentiment				1.121***
				(0.341)
Observations	248	248	186	186

Standard errors in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

A.2.4 Industry Classifications

NOGA 2008 2-digit	WK08 group	BFS/Eurostat 11 group
10 - Manufacture of food products	Food/Beverages/Tobacco	Manufacturing
11 - Manufacture of beverages	Food/Beverages/Tobacco	Manufacturing
12 - Manufacture of tobacco products	Food/Beverages/Tobacco	Manufacturing
13 - Manufacture of textiles	Textiles/Clothing	Manufacturing
14 - Manufacture of wearing apparel	Textiles/Clothing	Manufacturing
15 - Manufacture of leather and related products	Textiles/Clothing	Manufacturing
16 - Manufacture of wood and of products of woo...	Wood	Manufacturing
17 - Manufacture of paper and paper products	Paper	Manufacturing
18 - Printing and reproduction of recorded media	Printing	Manufacturing
19 - Manufacture of coke and refined petroleum ...	Chemicals	Manufacturing
20 - Manufacture of chemicals and chemical prod...	Chemicals	Manufacturing
21 - Manufacture of basic pharmaceutical produc...	Pharmaceuticals	Manufacturing
22 - Manufacture of rubber and plastic products	Rubber/Plastics	Manufacturing
23 - Manufacture of other non-metallic mineral ...	Non-metallic Minerals	Manufacturing
24 - Manufacture of basic metals	Basic Metals	Manufacturing
25 - Manufacture of fabricated metal products, ...	Fabricated Metals	Manufacturing
26 - Manufacture of computer, electronic and op...	Electronic and Optical Products	Manufacturing
27 - Manufacture of electrical equipment	Electrical Equipment	Manufacturing
28 - Manufacture of machinery and equipment n.e.c.	Machinery & Equipment	Manufacturing
29 - Manufacture of motor vehicles, trailers an...	Vehicles	Manufacturing
30 - Manufacture of other transport equipment	Vehicles	Manufacturing
31 - Manufacture of furniture	Other Manufacturing	Manufacturing
32 - Other manufacturing	Other Manufacturing	Manufacturing
33 - Repair and installation of machinery and e...	Repair/Installation	Manufacturing
35 - Electricity, gas, steam and air-conditioni...	Energy	Electricity, gas, steam and air conditioning su...
36 - Water collection, treatment and supply	Water/Environment	Water supply, sewerage, waste management and re...
37 - Sewerage	Water/Environment	Water supply, sewerage, waste management and re...
38 - Waste collection, treatment and disposal a...	Water/Environment	Water supply, sewerage, waste management and re...
39 - Remediation activities and other waste man...	Water/Environment	Water supply, sewerage, waste management and re...
41 - Construction of buildings	Construction	Construction
42 - Civil engineering	Construction	Construction
43 - Specialised construction activities	Construction	Construction
45 - Wholesale and retail trade and repair of m...	Wholesale Trade	Trade, repair of motor vehicles and motorcycles
46 - Wholesale trade, except of motor vehicles ...	Wholesale Trade	Trade, repair of motor vehicles and motorcycles
47 - Retail trade, except of motor vehicles and...	Retail Trade	Trade, repair of motor vehicles and motorcycles
49 - Land transport and transport via pipelines	Transportation	Transportation and storage; Information and com...
50 - Water transport	Transportation	Transportation and storage; Information and com...
51 - Air transport	Transportation	Transportation and storage; Information and com...
52 - Warehousing and support activities for tra...	Transportation	Transportation and storage; Information and com...
53 - Postal and courier activities	Telecommunications	Transportation and storage; Information and com...
55 - Accommodation	Accommodation/Restaurants	Accommodation and food service activities
56 - Food and beverage service activities	Accommodation/Restaurants	Accommodation and food service activities
58 - Publishing activities	Publishing/Media	Transportation and storage; Information and com...
59 - Motion picture, video and television progr...	Publishing/Media	Transportation and storage; Information and com...
60 - Programming and broadcasting activities	Publishing/Media	Transportation and storage; Information and com...
61 - Telecommunications	Telecommunications	Transportation and storage; Information and com...
62 - Computer programming, consultancy and rela...	Information Technology/Services	Transportation and storage; Information and com...
63 - Information service activities	Information Technology/Services	Transportation and storage; Information and com...
64 - Financial service activities, except insur...	Banks/Insurance	Financial service activities
65 - Insurance, reinsurance and pension funding...	Banks/Insurance	Insurance service activities
68 - Real estate activities	Real Estate/Rental&Leasing	Real estate, professional, scientific and techn...
69 - Legal and accounting activities	Other Commercial Services	Real estate, professional, scientific and techn...
70 - Activities of head offices; management con...	Other Commercial Services	Real estate, professional, scientific and techn...
71 - Architectural and engineering activities; ...	Technical Commercial Services	Real estate, professional, scientific and techn...
72 - Scientific research and development	Technical Commercial Services	Real estate, professional, scientific and techn...
73 - Advertising and market research	Other Commercial Services	Real estate, professional, scientific and techn...
74 - Other professional, scientific and technic...	Other Commercial Services	Real estate, professional, scientific and techn...
77 - Rental and leasing activities	Real Estate/Rental&Leasing	Real estate, professional, scientific and techn...
78 - Employment activities	Other Commercial Services	Real estate, professional, scientific and techn...
79 - Travel agency, tour operator reservation s...	Transportation	Real estate, professional, scientific and techn...
80 - Security and investigation activities	Other Commercial Services	Real estate, professional, scientific and techn...
81 - Services to buildings and landscape activi...	Real Estate/Rental&Leasing	Real estate, professional, scientific and techn...
82 - Office administrative, office support and ...	Other Commercial Services	Real estate, professional, scientific and techn...
86 - Human health activities	Human health activities	Human health and social work activities
90 - Creative, arts and entertainment activities	Arts, entertainment, and recreation	Arts, entertainment and recreation
91 - Libraries, archives, museums and other cul...	Arts, entertainment, and recreation	Arts, entertainment and recreation
92 - Gambling and betting activities	Arts, entertainment, and recreation	Arts, entertainment and recreation
93 - Sports activities and amusement and recrea...	Arts, entertainment, and recreation	Arts, entertainment and recreation
95 - Repair of computers and personal and house...	Retail Trade	Other service activities
96 - Other personal service activities	Personal Services	Other service activities

Table 17: Correspondence between NOGA 2008 2-digit codes and the two aggregations used throughout the paper. For the sectors human health activities and arts, entertainment, and recreation (NOGA codes 86 and 90-93) we do not have survey results.

A.2.5 Kurzarbeit Across Sectors

Date Sector name	2020-01	2020-02	2020-03	2020-04	2020-05	2020-06	2020-07	2020-08	2020-09	2020-10	2020-11	2020-12	2021-01	2021-02	2021-03	2021-04
Accommodation/Restaurants	0.00	0.00	0.32	0.66	0.44	0.22	0.14	0.12	0.07	0.09	0.22	0.27	0.41	0.38	0.39	0.29
Arts, entertainment, and recreation	0.00	0.00	0.19	0.41	0.32	0.14	0.08	0.06	0.04	0.04	0.12	0.16	0.22	0.22	0.20	0.11
Banks/Insurance	0.00	0.00	0.01	0.03	0.03	0.01	0.01	0.01	0.00	0.00	0.01	0.00	0.01	0.01	0.01	0.00
Basic Metals	0.01	0.01	0.08	0.22	0.17	0.14	0.10	0.07	0.06	0.05	0.06	0.04	0.03	0.02	0.02	0.02
Chemicals	0.00	0.00	0.01	0.06	0.05	0.04	0.02	0.02	0.02	0.01	0.02	0.01	0.01	0.01	0.01	0.01
Construction	0.00	0.00	0.07	0.14	0.06	0.02	0.02	0.01	0.01	0.01	0.01	0.01	0.01	0.02	0.01	0.01
Electrical Equipment	0.00	0.00	0.02	0.08	0.08	0.06	0.04	0.03	0.03	0.03	0.02	0.02	0.02	0.02	0.02	0.01
Electronic and Optical Products	0.00	0.00	0.10	0.27	0.20	0.16	0.11	0.08	0.08	0.06	0.05	0.04	0.04	0.04	0.04	0.02
Energy	0.00	0.00	0.01	0.02	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Fabricated Metals	0.00	0.00	0.06	0.16	0.12	0.09	0.06	0.06	0.05	0.05	0.05	0.03	0.04	0.03	0.03	0.02
Food/Beverages/Tobacco	0.00	0.00	0.06	0.14	0.10	0.05	0.03	0.02	0.01	0.01	0.03	0.04	0.07	0.07	0.06	0.04
Human health activities	0.00	0.00	0.04	0.09	0.03	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Information Technology/Services	0.00	0.00	0.02	0.08	0.08	0.05	0.04	0.03	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.01
Machinery & Equipment	0.00	0.01	0.04	0.13	0.13	0.10	0.07	0.06	0.06	0.05	0.05	0.03	0.04	0.03	0.03	0.02
Non-metallic Minerals	0.00	0.00	0.04	0.10	0.05	0.02	0.01	0.01	0.01	0.01	0.01	0.00	0.01	0.01	0.01	0.00
Other Commercial Services	0.00	0.00	0.07	0.19	0.13	0.07	0.05	0.03	0.02	0.02	0.03	0.03	0.05	0.06	0.04	0.03
Other Manufacturing	0.00	0.00	0.09	0.27	0.18	0.11	0.07	0.05	0.04	0.03	0.04	0.03	0.04	0.05	0.04	0.02
Paper	0.00	0.00	0.01	0.05	0.06	0.06	0.04	0.03	0.02	0.02	0.02	0.01	0.01	0.02	0.01	0.01
Personal Services	0.00	0.00	0.21	0.38	0.12	0.06	0.05	0.04	0.02	0.02	0.06	0.05	0.07	0.07	0.06	0.04
Pharmaceuticals	0.00	0.00	0.00	0.01	0.01	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Printing	0.00	0.00	0.06	0.21	0.18	0.12	0.09	0.07	0.05	0.05	0.05	0.04	0.08	0.09	0.08	0.05
Publishing/Media	0.00	0.00	0.05	0.17	0.15	0.09	0.07	0.06	0.04	0.04	0.04	0.04	0.05	0.06	0.05	0.04
Real Estate/Rental&Leasing	0.00	0.00	0.07	0.16	0.10	0.05	0.04	0.03	0.02	0.02	0.03	0.03	0.04	0.04	0.04	0.03
Repair/Installation	0.00	0.00	0.04	0.14	0.11	0.08	0.06	0.05	0.04	0.04	0.04	0.04	0.05	0.04	0.04	0.03
Retail Trade	0.00	0.00	0.10	0.20	0.11	0.04	0.03	0.02	0.01	0.01	0.02	0.03	0.07	0.09	0.03	0.02
Rubber/Plastics	0.00	0.00	0.03	0.09	0.07	0.05	0.03	0.02	0.02	0.02	0.02	0.01	0.01	0.01	0.01	0.01
Technical Commercial Services	0.00	0.00	0.03	0.09	0.06	0.03	0.02	0.02	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Telecommunications	0.00	0.00	0.01	0.02	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Textiles/Clothing	0.00	0.00	0.15	0.40	0.25	0.15	0.10	0.10	0.07	0.06	0.08	0.06	0.13	0.19	0.10	0.07
Transportation	0.00	0.00	0.08	0.21	0.17	0.13	0.10	0.08	0.08	0.08	0.09	0.08	0.10	0.09	0.09	0.07
Vehicles	0.00	0.00	0.03	0.15	0.10	0.05	0.04	0.03	0.02	0.02	0.01	0.01	0.01	0.01	0.01	0.01
Water/Environment	0.00	0.00	0.03	0.07	0.04	0.02	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Wholesale Trade	0.00	0.00	0.07	0.21	0.13	0.06	0.04	0.03	0.02	0.02	0.03	0.03	0.04	0.06	0.04	0.02
Wood	0.00	0.00	0.04	0.10	0.05	0.02	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.00

Table 18: Hours lost due to short term work (Kurzarbeit) as a share of total hours worked, across industries and time.