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Abstract

This paper investigates the causal effect of global value chain (GVC)-related trade on the German labor market during the COVID-19 crisis, using a difference-in-differences approach combined with entropy balancing. The analysis of monthly establishment-level data from January 2019 to December 2021 shows that a one standard deviation increase in GVC-related trade with China leads to an increase in short-time work of up to 27 percentage points, with significant positive effects observed from May to October 2020. For this period, the regression results imply that a one standard deviation increase in GVC integration gives rise to an additional expenditure on short-time work of around 7.3 billion euros. In contrast, GVC-related trade with the whole world as a trading partner does not show a significant impact. Additional survey data support these findings, suggesting that establishments that are more GVC-integrated with China face more difficulties in obtaining inputs or dealing with suppliers in 2020.

Zusammenfassung

Diese Studie untersucht mit Hilfe eines Differenz-in-Differenzen-Ansatzes in Kombination mit Entropy Balancing den kausalen Effekt von globalen Wertschöpfungsketten (GVC) auf den deutschen Arbeitsmarkt während der COVID-19-Krise. Die Analyse von monatlichen Betriebsdaten von Januar 2019 bis Dezember 2021 zeigt, dass ein Anstieg des GVC-bezogenen Handels mit China um eine Standardabweichung zu einem Anstieg der Kurzarbeit um bis zu 27 Prozentpunkte führt, wobei die Effekte von Mai bis Oktober 2020 signifikant positiv sind. Für diesen Zeitraum würde den Regressionsergebnissen zufolge ein Anstieg um eine Standardabweichung zu zusätzlichen Ausgaben für Kurzarbeit in Höhe von rund 7,3 Milliarden Euro führen. Im Gegensatz dazu ergeben sich für den GVC-bezogene Handel mit der Welt als Handelspartner keine signifikanten Effekte. Zusätzliche Befragungsdaten stützen die Ergebnisse und deuten darauf hin, dass Betriebe, die stärker in GVCs mit China eingebunden sind, im Jahr 2020 mehr Schwierigkeiten bei der Beschaffung von Vorleistungen oder bei der Zusammenarbeit mit Lieferanten hatten.

JEL

F16, F61, D57, C22, C23

Keywords

COVID-19 Crisis, German Labor Market, Global Value Chains, Short-Time Work, Difference-in-Differences

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1 Introduction

In December 2019, a new coronavirus emerged in Wuhan, China. Not even four months later, the World Health Organization declared the resulting novel viral disease (COVID-19) a pandemic. Not long later, lockdowns and closed borders affected almost every country in the world. Global trade largely came to a standstill. The impact was so great that *The Economist* asked on 14th of May 2020: *"Has COVID-19 killed globalization?"* (The Economist, 2020). In the second quarter of 2020, global trade in goods fell by about 12 percent compared to the last quarter of 2019. In particular, the volatility of trade in goods that rely heavily on global value chains (GVCs) was high (International Monetary Fund, 2022). In addition, Bonadio et al. (2021) show that countries and economic sectors were more negatively affected if the trading partner in GVC-related trade had stronger and longer lockdowns. These negative consequences, especially at the beginning of the crisis, have renewed the debate on the costs and benefits of globalization in general and on the dependence of GVCs in particular (Arriola et al., 2020). As a result, there is now a debate as to whether increased domestic production, "reshoring", or greater diversification of GVCs will cushion the negative impact of future shocks (Essletzbichler et al., 2021; Alvarez/Biurrun/Martín, 2022).

Within this growing canon of literature, the impact on the labor market of a country that is highly integrated in GVCs, such as Germany, has not yet been considered. The integration of Germany in international trade of goods and services is of great importance and has increased in the last two decades. The share of imported and exported goods and services with respect to GDP increased from 32 percent in 2001 to 47 percent in 2021. In the same period, the average of all OECD countries increases from 22 percent in 2001 to 30 percent in 2021 (OECD, 2023). Further, there is a lack of empirical evidence on whether the disruptions of GVCs during the pandemic differ between trading partners. This paper aims to fill this gap in the literature and empirical research. In particular, I analyze the specific role of China for the German labor market compared to the general integration in GVCs for the German economy. China is of great interest even after the pandemic, according to a European Central Bank survey. European firms mention China most frequently in terms of perceived risks, either in the company's own supply chain or that of its economic sector. In addition, firms responded that China is the dominant source of critical input (European Central Bank, 2023).

This paper focuses on the economic effects of the disruptions of GVCs during the COVID-19 crisis and the related impact on the German labor market. I investigate whether the level of integration into GVCs has influenced short-time work (STW) of establishments in Germany

during the pandemic.[1] To identify the causal effect of GVC-related trade on the level of STW during the COVID-19 pandemic, I exploit the sectoral variation in GVC-related trade in a difference-in-differences (DiD) setup. The empirical strategy consists of a DiD model with a continuous treatment exposure combined with entropy balancing and time-varying regional control variables. I use monthly information on short-time work from January 2019 to December 2021 and combine it with the OECD Inter-Country Input-Output tables that provide information on GVC-related trade (OECD, 2022). In addition, survey information from the Institute for Employment Research (IAB) Establishment Panel and process data from the IAB Establishment History Panel are used to control for establishment heterogeneity.

The results indicate that German establishments register more STW from May 2020 to October 2020 if they are located in economic sectors that rely more on GVC-related trade with China. During that time, an increase in GVC-related trade with China of one standard deviation increases the share of STW by up to 26.9 percentage points. However, the significant effects observed for GVC-related trade with China are temporary and already decline during the second half of 2020. For the period when the effects are significantly different from zero, from May to October 2020, a one standard deviation higher GVC-related trade with China gives rise to an additional spending of approximately 7.3 billion euros on STW according to the regression results. In contrast to GVC-related trade with China, there is no significant relation between STW and worldwide (excluding China) GVC-related trade for German establishments during the pandemic. The results support the findings of other studies which suggest that policies such as “reshoring” large parts of global value chains are probably misguided. Instead, supply chain resilience to shocks is better built by increasing diversification. Efficient strategies could include easier supply and demand switching between trade partners and reducing bottlenecks along the value chains by increasing the number of trade partners (International Monetary Fund, 2022; Lebastard/Matani/Serafini, 2023).

The remainder of this paper proceeds as follows. Section 2 provides a brief overview of the evidence on the economic effects of GVC disruptions caused by the pandemic and discusses how the paper adds to the literature. In Section 3, I describe the data sources and how I link them, while I explain the indicators applied to measure the integration of GVC in Section 4. In Section 5, I describe the empirical model and the identification strategy. Section 6 presents and discusses the results of the regression analysis. Section 7 provides further insight into the mechanism behind the results. In addition, some robustness are presented in this section. Section 8 concludes.

[1] Establishment is the unit of observation in the analysis. An establishment might be a branch of a company in a specific location. This also includes parts of a company that are affiliated locally and organizationally. At least one employee must work on behalf of the company (Destatis, 2024).

2 Literature review

This paper contributes to the literature on the economic impact of the COVID-19 pandemic due to the breakdown of international trade via disruptions of global value chains (see, among many others, Bonadio et al., 2021; Eppinger et al., 2021; Meinen/Serafini/Papagalli, 2021; Meier/Pinto, 2020; Lebastard/Matani/Serafini, 2023).
A value chain can be defined as the series of stages in the production of a good or service for end use. Each stage adds value to the good or service. If at least two stages take place in different countries, the value chain can be designated as a global value chain (GVC) (World Bank, 2020). Participating in GVCs can have several advantages for countries and companies. The literature mentions, among others, lower input costs (Antràs/Chor, 2013; Gereffi/Humphrey/Sturgeon, 2005), a higher degree of specialization (Koopman/Wang/Wei, 2014), access to new markets (Baldwin/Venables, 2013) and better knowledge and technology transfer (Ernst/Kim, 2002). For Germany with its export-oriented growth model, these advantages of GVCs have been a key factor in the country's economic success over the last decades.

The COVID-19 pandemic had significant consequences for GVCs. Lockdowns, firm closures and closed borders led to an almost complete standstill in global trade. Companies for which international trade plays a major role in their value chains should have been particularly negatively affected by these circumstances. They have problems exporting intermediate goods and suffered from a lack of intermediate goods for their own production (Lebastard/Matani/Serafini, 2023). Several studies give empirical evidence that higher participation in GVCs amplified economic contagion during the crisis. Espitia et al. (2022) used trade data for 28 exporting countries at the sector level between February and June 2020. They use a gravity model with a comprehensive set of fixed effects to investigate the role of sector characteristics that likely influence the size of the COVID-19 shock. Among others, they find that while participation in GVC increased an exporter's vulnerability to foreign shocks, it reduced vulnerability to domestic shocks in the short run.
Kejžar/Velić/Damijan (2022) also use a gravity model and find results that go in the same direction. They show that forward GVC linkages act as a channel for the transmission of shocks in GVC trade. An increase in the incidence of COVID-19 cases in the destination country leads to a larger decrease in domestic exports of intermediate goods in those countries with which a country has stronger forward linkage in GVCs.
Lebastard/Matani/Serafini (2023) use monthly transaction-level data for the universe of French export firms. They apply a difference-in-differences methodology, as well as a logit model, to identify the causal effects of supply chain linkages on exporter performance and the probability of survival in the export market during the crisis. They show that participation in GVCs increased the firms' vulnerability to the COVID-19 shock in both export

performance and survival probability. Meinen/Serafini/Papagalli (2021) analyze regional labor market outcomes in France, Germany, Italy, and Spain. They use monthly data on regional short-time work for the first phase of the pandemic. They find that the stringency of government containment measures does not fully explain the impact of the pandemic on regional labor markets. They show that the regional economic structure and trade linkages help to explain the regional within-country heterogeneity of the labor market impact. Regions that are highly integrated in supply chains with foreign regions hit hard by the pandemic showed the worst labor market outcomes.

Within this literature, some studies emphasize China's special role as a trading partner in value chains during the pandemic (see among others, Meinen/Serafini/Papagalli, 2021; Eppinger et al., 2021; Kejžar/Velić/Damijan, 2022). Following the argumentation of Bonadio et al. (2021), relying on China in GVCs should have negative effects on the trade partner, since China was hit hard by the pandemic, particularly in the early phase. Kejžar/Velić/Damijan (2022) call it the "China effect". They provide evidence that shock transmission is amplified if the exporting country shows a high share of supply chain trade with China. Eppinger et al. (2021) and Gerschel/Martinez/Mejean (2020) study the propagation of the production slowdown in the Chinese province of Hubei to the global economy through global trade and GVCs. Lafrogne-Joussier/Martin/Mejean (2023) use transaction-level import and export data from French firms and use the early lockdown in China as an exogenous shock to quantify the causal effect of GVC disruptions on exports and domestic sales. Firms sourcing their input from China experienced a drop in exports compared to GVC firms importing inputs from other countries in April 2020. The reasons for the drop are a reduction in the number of products shipped or a temporary exit from specific destination markets.

Following Lafrogne-Joussier/Martin/Mejean (2023), this paper also considers China as the main analyzed trade partner compared to general worldwide trade, the study makes several contributions to the literature. First, this paper analyzes the effects of GVC disruptions during the pandemic for German companies. So far, evidence on Germany, an important agent in GVCs, is scarce. The role of China in German GVCs is particularly important. In recent years, China has become Germany's most important trading partner in international trade in goods. According to a survey by the *ifo Institute*, 46 percent of all German manufacturing companies are currently relying on important input from China (Baur/Flach, 2022). Second, this paper looks at the impact on the labor market for German firms while the previous literature has focused mainly on changes in international trade. It attempts to provide an answer to the question of whether GVC integration led to negative labor market outcomes during the COVID-19 pandemic. Third, this paper covers the full years 2020 and 2021 while most earlier studies investigate the impact of the initial shock in spring 2020. With a longer observation period, it is possible to examine the duration of the effects not only in the sort run, but also in the medium-time phase.

3 Data

This section describes the different datasets that are used and explains how they are merged for the analysis. The dataset for the main analysis contains information on short-time work (STW) for establishments on a monthly level. In addition, the dataset includes time-varying information on labor market regions during the COVID-19 pandemic. Due to a standardized establishment identifier, it is possible to link survey information from the IAB Establishment Panel (BP) and process data from the IAB Establishment History Panel (BHP) to the STW dataset. Furthermore, the industry classification (ISIC Rev.4) of the establishments is used to merge global value chain indicators generated by the OECD's Inter-Country Input-Output (ICIO) database.[2]

3.1 Monthly panel data

Short-time work is one of the most important labor market policy instruments to avoid mass layoffs during major economic crises. One reason why the unemployment rate showed a relatively moderate increase during the COVID-19 pandemic in Germany was the extensive use of STW. The main mechanism of STW is that governments temporarily subsidize a portion of the employers payrolls when labor demand declines during the crisis. In Germany, establishments that have to reduce the working hours of their employees can apply for subsidies from the Federal Employment Agency (FEA) (Naujoks/Kreyenfeld/Dummert, 2022). The data is based on payroll lists and is collected on the basis of claims. I use only realized STW claims. This means that only claims that actually resulted in a wage subsidy are taken into account. In the data, it is also possible to distinguish between STW claims for structural economic reasons, such as seasonal STW in the construction sector, and STW for non-structural economic reasons, the so-called cyclical STW (Federal Employment Agency, Statistics/Labour Market Reporting, 2021). The cyclical part of the STW reports is therefore suitable as a performance indicator at the establishment level and is used as the main outcome variable in the analysis.

For the analysis, a balanced panel is constructed for the period from January 2019 until December 2021. The main variable is the share of workers in STW in a given month divided by the number of all workers in June 2019.[3] An advantage of the dataset is that it contains a unique establishment identifier, which can be used to merge establishment information

[2] A detailed overview of the sample restrictions for the datasets is presented in Section A.1 and for summary statistics, Section A.3 in the appendix.
[3] See Section A.1 for sample restrictions and numbers of observations.

from datasets such as the IAB Establishment Panel (BP) and the IAB Establishment History Panel (BHP).

During the COVID-19 pandemic, establishments faced different restrictions depending on the region of Germany where they were located. To account for that, I add three additional time-varying variables at the labor market region level for each month. I consider a measure of the regional strictness of measures imposed to contain the spread of the pandemic, i.e., the stringency index available in the *Corona Datenplattform*[4]. It is calculated taking the mean value of 23 different policy responses and ranges from 0 to 100 where higher values indicate higher levels of strictness. From the same data source, I also use the number of monthly reported COVID-19 infections. In addition, I use daily mobility flows, which are derived from mobile phone data by the mobile phone provider *Telefónica* and prepared by the *Teralytics GmbH* (for more information, see Brockmann/Robert Koch Institute, 2022). The data enables me to include changes in mobility with reference to the average daily mobility in the corresponding month in 2019. To receive monthly data, I calculate the mean on all days of the relevant month.

3.2 Yearly establishment data

In addition to the monthly panel dataset, I set up an establishment dataset for 2019. This serves primarily as the basis for the entropy balancing explained in Chapter 5.2. All establishment characteristics in the dataset are measured in the year 2019. This is the year directly before the crisis and therefore measures the characteristics of the establishment that have not yet been affected by the COVID-19 pandemic.

First, I use the IAB Establishment Panel (BP) which is an annual survey on the establishment level for Germany. It covers a representative share of all establishments in Germany and is also representative for all sectors and establishment sizes (Ellguth/Kohaut/Möller, 2014; Fischer et al., 2009).[5] For the analysis, the survey wave 2020 is used. It contains, among other things, information on the proportion of business volume achieved outside of Germany and the share of sales that is attributed to intermediate inputs and external costs from the previous financial year, that is, 2019.[6]
The second dataset is the IAB Establishment History Panel (BHP) which covers all establishments throughout Germany with at least one employee subject to social security as of 30 June of a given year. The data source for the BHP is the employee history datasets

[4] For more information on the data, see https://www.healthcare-datenplattform.de/.
[5] For technical information on the dataset see Gensicke et al. (2022).
[6] These two variables are particularly important but they suffer problems with missing values. To keep the representativity of the sample, I replace the missing observations with the mean of all non-missing observations. For further information, see Section A.2.

of the IAB. The individual employee information contained in the employee history datasets is aggregated yearly to the establishment level (Ganzer et al., 2022). Overall, 6,736 establishments can be merged with the BP using the unique establishment identifier. The BHP covers detailed information on the employee composition and on wages. Here, I use the share of managers, high- and medium-skilled workers, employees in highly complex tasks, in (science, technology, engineering or math) STEM occupations and with university degree. In addition, I use the 25th, 50th and 75th percentile of the establishment wage distributions.

To account for other channels which could influence the establishment performance during the COVID-19 pandemic further variables are added. I use the distance to an early hot spot of the COVID-19 pandemic, Bergamo, for each German municipality to capture the regional variation in the spread of the pandemic over space (Felbermayr/Hinz/Chowdhry, 2021). I assign the distance according to where the establishments are located. The loss of value added is taken from Bauer/Weber (2021). It indicates the change in the gross value added of every industry caused by the hypothetical closures via their linkages in an input-output table to all other industries in Germany. This describes the affectedness of an industry when other industries close on a national level and could be regarded as domestic spillover effects. Furthermore, I include the working from home capacity (WfH) from Alipour/Falck/Schüller (2023). The index assigns a level of capacity of how much could be worked from home to each ISIC industry and I match them via the industry information to each establishment. Finally, I add an establishment effect that controls for the establishment-specific wage premia by using firm information from 2010-2017 (Abowd/Kramarz/Margolis, 1999; Bellmann et al., 2020; Card/Heining/Kline, 2013).

3.3 OECD's Inter-Country Input-Output (ICIO) database

To measure in which way different different economic sectors in Germany are integrated into global value chains (GVCs), I use the 2022 edition of the OECD Inter-Country Input-Output (ICIO) tables which provide information for 76 single countries and a term which summarizes the rest of the world. For the year 2019, the dataset covers 93 percent of the worldwide GDP, 92 percent of all exports and 90 percent of all imports. The time span of the dataset ranges from 1995 until the year 2020 (OECD, 2022).[7] The input-output tables show the monetary amount of input to produce the final amount of output of a specific industry. Further, they decompose output into final consumption and intermediate goods and combine national input-output tables to describe the sale-purchase relationships between and within industries and countries (Belotti/Borin/Mancini, 2020). The dataset provides the basis for calculating the indices to measure GVC integration that are described

[7] For more information on the latest OECD ICIO database, see http://oe.cd/icio.

in Section 4. The OECD ICIO contains 45 economic sectors according to the ISIC Rev.4 classification, which also serves as the identifier to match the indices to the establishments.

4 Measuring GVC-related trade

In this section, I describe how I measure the participation of industries in global value chains (GVCs). GVCs are measured as part of international trade flows and the definition of what should be considered a trade flow related to GVC activities originates from Hummels/Ishii/Yi (2001). The idea is that goods and services must cross an international border more than once during the production process to be regarded as GVC-related activities.

In this analysis, I use the indices proposed by Borin/Mancini (2015, 2019) and Borin/Mancini/Taglioni (2021). The authors use the concept of GVC-related trade via the exporting sector to identify the level of GVC integration of a specific industry. As a starting point, they use the gross exports ($GEXP^{ev}$) of the exporter country e to a trading partner v. In the setup used in this analysis, e is always equal to Germany and therefore neglected in the following. The trading partner can have different levels of aggregation. It could be either a specific country, a group of countries like the OECD or the entire world.

In a second step, they derive the domestic value-added absorbed directly by the importer ($DAGEXP^v$) as a part of the gross exports. Following the authors, this part of gross export is *not* part of GVC-related trade and therefore $DAGEXP^v$ includes:

- Exports that are produced in Germany and consumed abroad.
- Intermediate goods that are produced in Germany and used by the importing country to produce final goods for its domestic market (Borin/Mancini, 2019).

Conversely, the remaining part of the gross exports ($GVCGEXP^v$) is related to GVC, that is, it crosses more than one border:

$$GVCGEXP^v = GEXP^v - DAGEXP^v \tag{1}$$

Regarding bilateral trade flows e.g. from Germany to China that are related to GVC activities $GVCGEXP^v$ involves accounting for double-counting as value-added produced and exported by a country might be re-imported and further processes by this country in later stages of the GVC. Suppose, for example, that along the production process, a certain intermediate input is shipped from country A first to country B where it is processed and

then shipped back to country A. Afterwards, the good is finalized and then shipped to country C. In this case, when a portion of the good crosses the border of the same country more than once, it has to be assigned to the flow of one country, whereas it is corrected as *"double counted"* in the other countries. To control for this, Borin/Mancini (2019) use the so-called source-based approach by Nagengast/Stehrer (2016) to calculate their GVC indices. The rational behind the source-based approach is that the generated value-added is recorded as closely as possible to the moment when it is produced.

To measure the relative importance of GVCs in all exports, GVC-related trade can be expressed as a fraction of gross exports.[8] This has the favorable feature that the index expresses a relative measure and is bounded between zero and one. The share of GVC-related trade (GVC^v) in gross exports is given by:

$$GVC^v = \frac{GVCGEXP^v}{GEXP^v} \tag{2}$$

Further, the index allows a flexible decomposition from the global measure to country-, sector- and country-sector-specific measures.[9] This allows me to consider GVC connections between pairs of countries such as China and Germany as well as for specific industries.

5 Empirical strategy

To identify the causal effect of GVC-related trade on the level of short-time work (STW) during the COVID-19 pandemic, I exploit the sectoral variation in GVC-related trade in a difference-in-differences (DiD) setup. The empirical strategy consists of a DiD model with a continuous treatment exposure combined with entropy balancing for continuous treatments (EBCT) and time-varying regional control variables. The entropy balancing weights and controls are included in a two-way fixed effects (TWFE) model in a standard event-study specification. The strategy allows the identification of effects by making establishments comparable in their pre-crisis characteristics due to the weighting.

[8] In the paper, GVC-related exports and GVC-related trade are used interchangeably.

[9] I would like to thank Federico Belotti, Alessandro Borin and Michele Mancini for providing the ICIO package, which allows me to calculate all relevant indices.

5.1 Difference-in-differences estimation

Like in all DiD setups, the crucial assumption is the parallel trends assumption which says that in absence of the treatment the differences between the treatment and control groups are the same over time. However, the assumption needs to be adjusted in this analysis because the treatment, GVC-related trade, is continuous and a non-treatment group is not existent. Callaway/Goodman-Bacon/Sant'Anna (2024) modify the assumption for continuous treatments and call it the strong parallel trends assumption, which must be met to identify an average treatment effect on the treated (ATT). Applied to this study, I assume that establishments with different levels of GVC-related trade would show the same trends in STW if they had been exposed to the same level of GVC-related trade and if the COVID-19 shock had not occurred. In other words, I could say that, in the absence of the COVID-19 crisis, STW would have followed parallel trends along all levels of GVC-related trade.

As a preliminary check for the assumption of parallel trends, I report leads of the effect of GVC-related trade on STW in an event-study plot and look for any recognizable differences. In addition, I alter the continuous treatment specification to a binary treatment specification (similar to Bauernschuster/Hener/Rainer, 2016). This is done because the binary treatment specification relies on a weaker parallel trends assumption, since the identification of the effect only comes from a dichotomous change in the treatment. In contrast, the effect in the continuous specification comes from a level and a dose effect simultaneously (for a formal derivation, see Callaway/Goodman-Bacon/Sant'Anna, 2024). I generate a binary indicator equal to one if GVC-related trade is higher than a certain threshold. Then, one indicates sectors with high GVC-related trade, the treatment group, and zero indicates sectors with low GVC-related trade, the control group. The TWFE model in the event-study design for the binary treatment specification is then given by:

$$STW_{it} = \sum_{t \neq 2020m2} \beta_t \mathbb{1}(t = T) \times \mathbb{1}(GVC^v_{s(i)} > T(p)) + \gamma_i + \tau_t + \epsilon_{it} \tag{3}$$

In Equation (3), STW_{it} is the share of short-time work in total employment in establishment i and month t.[10] $GVC^v_{s(i)}$ represents the GVC-related trade of an establishment with a partner country v. The value is assigned through the sector s of establishment i. $\mathbb{1}(GVC^v_{s(i)} > T(p))$ is an indicator function that is equal to one if GVC-related trade exceeds the threshold $T(p)$. Since there is no general rule for a threshold that defines low- and high-GVC-related trade, two different thresholds are defined: For p I use the 40th and the 66th percentile of GVC-related trade.[11] The indicator function $\mathbb{1}(t = T)$ is equal to one if the running index t is equal to the month T under consideration. February 2020, the month

[10] I use a constant pre-crisis employment stock in June 2019 to calculate the share of short-time work.

[11] It is not possible to use thresholds lower than the 40th percentile. The 40th percentile is the lowest threshold where convergence in the binary model is achieved.

before the COVID-19 shock starts in Germany, serves as a reference. In addition, γ_i and τ_t are fixed effects for establishments and month-year pairs and ϵ_{it} is a white noise error term. The binary DiD setup in Equation (3) identifies the so-called intention-to-treat effects (ITTs), the effect of the treatment assignment on the outcome. This is the case because I assign the treatment, high vs. low GVC-related trade via thresholds to the sectors (or rather the establishments) and do not use the variation within the two groups (Angrist/Imbens/Rubin, 1996). The different thresholds can also serve as a first test for the assumed linearity or rather monotonicity of the dose effect for the treatment (Callaway/Goodman-Bacon/Sant'Anna, 2024). The size of the ITTs should increase with higher thresholds, since sectors with higher exposure to GVC-related trade should be more affected.

A straightforward approach to get closer to the ATTs is to use the full variation of the treatment and use a continuous DiD specification (Bauernschuster/Hener/Rainer, 2016). However, since the treatment, the GVC-related trade, is on the sector and not on the establishment level, the results do not perfectly represent the ATT.

$$STW_{it} = \sum_{t \neq 2020m2} \beta_t \mathbb{1}(t = T)\, GVC^{v}_{s(i)} + \gamma_i + \tau_t + \epsilon_{it} \tag{4}$$

Here, $GVC^{v}_{s(i)}$ is continuous and has any value between zero and one. In addition to the advantage that Equation (4) now exploits the entire variation of the treatment, it is not necessary to define an exact threshold for the division into control and treatment groups. Numerous factors other than GVC-related trade can influence the level of STW during the crisis (see e.g., Bartik et al., 2020; Partridge/Chung/Wertz, 2022; Kim/Lim/Colletta, 2022). For this reason, it is only possible to assume parallel trends if all other possible influencing factors are controlled for. This assumption is referred to as the conditional independence assumption (CIA), which is also known as the sorting or selection problem. During the COVID-19 pandemic, establishments faced different restrictions depending on the region in which they were located. To account for this, I add additional time-varying controls at the labor market region level for each month directly in Equation (4):

$$STW_{it} = \sum_{t \neq 2020m2} \beta_t \mathbb{1}(t = T)\, GVC^{v}_{s(i)} + \sum_{l=1}^{L} \beta_l CONT_{lr(i)t} + \gamma_i + \tau_t + \epsilon_{it} \tag{5}$$

where $CONT_{li(r)t}$ represents all L time-varying control variables for establishment i in region r. The controls are the COVID-19 infection rate, the policy response stringency index and regional mobility.[12]

[12] See Section 3.1 for a detailed description.

5.2 Entropy balancing for pre-crisis establishments characteristics

In addition to the time-varying controls, entropy balancing is used to control for a broad range of pre-crisis controls on the establishment level. The dataset and the variables are described in Section 3.2. The reason to weight establishments by their pre-crisis characteristics is driven by the CIA and also by the stable unit treatment value assumption (SUTVA) (Rubin, 1980). There could be concerns that even within a sector, there are differences between establishments that have the same level of treatment. These differences could affect the level of STW. According to the CIA, the effects of GVC-related trade on STW can only be interpreted as causal if they are conditioned on relevant establishment characteristics. The SUTVA points in the same direction: It implies that each unit receives the treatment in homogeneous doses. Thus, with regard to differences in establishments within the sectors, it is necessary to control for different characteristics of the establishments. Moreover, the SUTVA also requires that there are no spillovers. This means that the integration of one establishment in GVC-related trade does not affect the STW of other establishments. This can only be partly fixed by entropy balancing. Although it is not possible to model how establishments interact with each other, e.g. via intermediate inputs or outputs with the available data. In some cases, the change in the value-added variable might help to reduce the problem related to spillover effects. The variable indicates the change in the gross value added of every industry caused by the closures of all other industries in Germany. This might capture some pre-crisis spillover effects on the industry level but it does not control for spillovers on the establishment level as well as for changes during the crisis. Further, the SUTVA assumes that there are no general equilibrium effects. In the sample period, which is three years or rather just under two years after the shock, it seems to be plausible that long-term adjustment effects play only a minor role, if any at all.

Hainmueller (2012) derived entropy balancing for binary treatment variables. It relies on a maximum entropy weighting scheme that calibrates weights so that the re-weighted control group is equal in predefined moment conditions of the covariate distributions of the treatment group. Table 1 shows the results of the entropy balancing for GVC-related trade with China in the binary treatment specification. The condition is that the difference in the mean (first moment) of the treatment and the control group is minimized.

Taking into account the weights obtained from entropy balancing, a synthetic control group is created that represents a near perfect image of the treatment group in terms of the

Table 1: Balancing table for GVC-related trade with China (binary treatment)

	Mean differences			
	Pre p(40)	Post p(40)	Pre p(66)	Post p(66)
AKM firm-effects 2010-2017	-0.523	-0.000	-0.434	-0.000
Daily wage p(25)	-0.257	-0.000	-0.207	-0.000
Daily wage p(50)	-0.333	-0.000	-0.263	-0.000
Daily wage p(75)	-0.412	-0.000	-0.308	-0.000
Distance to Bergamo (km)	0.032	0.000	-0.024	0.000
Loss of value added	0.490	0.000	-0.915	0.000
Prop. business volume abroad	0.524	0.000	0.781	0.000
Prop. intermed. consump. of turnover(in %)	0.172	0.000	0.088	0.000
Share STEM occupations	-0.260	0.000	0.384	0.000
Share employees in highly complex tasks	-2.392	-0.001	-0.993	-0.001
Share high-skilled workers	-1.724	-0.001	-0.833	-0.001
Share managers	-0.615	-0.000	-0.420	-0.001
Share medium-skilled workers	0.214	0.000	0.147	0.000
Share professions with university degree	-14.265	-0.013	-14.438	-0.020
WfH Capacity	-0.289	-0.000	-0.103	-0.000

Note: The table shows the differences of the first moment (mean) between the treatment and the control group before and after entropy balancing. The first two columns show the differences when the treatment group is defined as GVC-related trade larger than the 40th percentile. Column three and four show the differences when the treatment group is defined as GVC-related trade larger than the 66th percentile.
Source: IAB Establishment Panel, IAB Establishment History Panel, Alipour/Falck/Schüller (2023) and OECD (2022); own calculations. ©IAB

establishment characteristics considered in the pre-crisis phase (post columns in Table 1).[13]

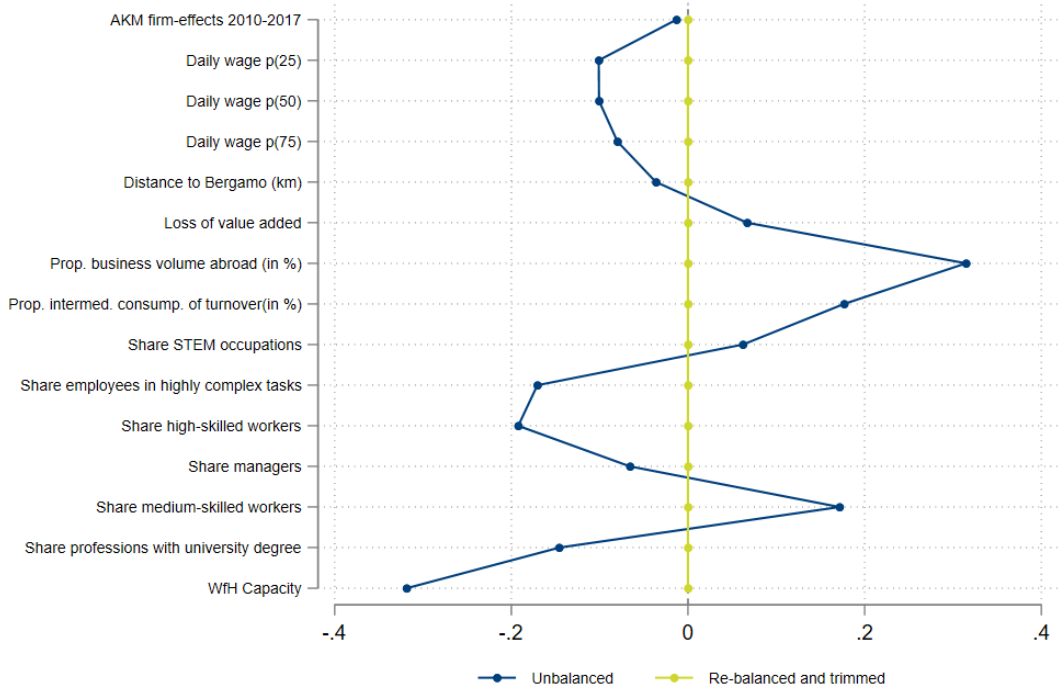
In the continuous case, I use entropy balancing for continuous treatments (EBCT) by Tübbicke (2021), which is an extension of the weighting procedure introduced by Hainmueller (2012). In the continuous case, the weighting uses only the variation of the treated observations, which is necessary in this analysis, since there are no untreated units. This has the advantage to balance the observations for certain doses of the treatment distribution (Tübbicke, 2021). EBCT first predicts GVC-related trade by using the characteristics of the establishment. Then, the algorithm iteratively minimizes the coefficient of determination (R^2) by assigning weights to each observation.
Further, the weights can also be interpreted in a slightly different way: Since the treatment is on the sector and not on the establishment level, I still identify an ITT of GVC-related trade on STW. This is the case because establishments within sectors still show different GVC integration. As EBCT explains the treatment by establishment characteristics, the weights could also be interpreted as a kind of inverse "compliance rate". For example, the volume of business abroad or the dependence of an establishment on intermediate goods will influence its vulnerability when GVCs break down and cause differences even within the

[13] The same holds in Table B.2 in the appendix when the treatment is GVC-related trade with the world without China.

same economic sector. If differences in these characteristics between establishments are taken into account, it is more likely that the true ATT is identified.

To describe the results of EBCT, Figure 1 shows the correlations between establishment characteristics and GVC-related trade with China before and after balancing. The blue line indicates the unweighted correlations. In the unweighted case, the R^2 is equal to 0.29. In contrast, the green line shows the correlations after weighting, which are all almost zero as the R^2. Moreover, in the model after weighting, I cannot reject the null hypotheses of a Wald test that all coefficients in the model are equal to zero. Consequently, this indicates that EBCT weights the establishments in a way that all observed pre-crisis characteristics are not informative anymore with respect to the level of STW.

Figure 1: Correlations before and after entropy balancing for GVC-related trade with China



Note: The weighted correlations are shown after excluding the establishments with the 1 percent smallest and largest weights. The summary statistics of the variables are listed in Table A.3.
Source: IAB Establishment Panel, IAB Establishment History Panel, Alipour/Falck/Schüller (2023) and OECD (2022); own calculations. ©IAB

The entropy balancing surely improves the identification of a causal effect of GVC-related trade, but it comes at some costs of another assumption: I have to make sure that it is possible to calculate relevant inverse probability weights. Figures B.5 and B.6 show the weight distribution for GVC-related trade with China and the world without China. The results show that most of the weights lie in a compact band. This indicates that there is common support for most establishments. To ensure that the results are not driven by

extreme weights, the sample is trimmed for the establishments with the 1 percent smallest and largest weights of the analysis (green markers) (Imbens, 2004; Tübbicke, 2021).

6 Results

6.1 Effects of GVC-related trade with China on STW

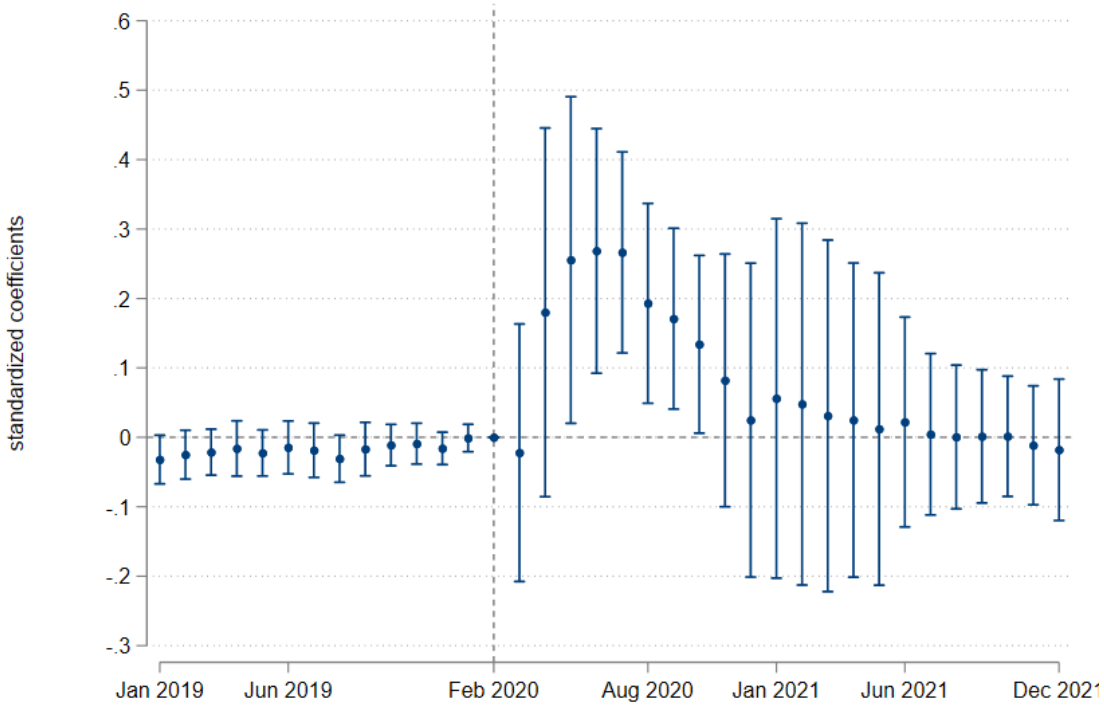
In this section, I investigate the relationship between GVC-related trade with China or the world (excluding China) and short-time work (STW). The results of the regression analysis are summarized in panel event study plots that show the estimated coefficients of GVC-related trade on STW from January 2019 to December 2021. In all plots, February 2020 is used as the reference month, and all variables are standardized with a mean of zero and a standard deviation of one. Furthermore, the bars around the point estimates indicate 95 percent confidence intervals and the standard errors are clustered on the sector level. The dependent variable is the percentage of workers in STW in a month using total employment in June 2019 as the denominator.

Figure 2 shows the relationship between STW and GVC-related trade with China in the continuous treatment specification of Equation (5). It includes the EBCT weights and the time-varying regional controls.[14] Prior to the crisis, GVC-related trade does not have a significant effect on STW. Thus, there are no major trends in the pre-crisis period, which supports the strong parallel trends assumption (Callaway/Goodman-Bacon/Sant'Anna, 2024). From April 2020 onward, the point estimates increase with a peak in June 2020 and remain statistically significant until October 2020. During this period, a 1 standard deviation increase in GVC-related trade with China increases the share of STW by 26.9 percentage points. After the peak, the effects of GVC-related trade with China decline until winter 2020. From December 2020 until the end of the observation time, the point estimates constantly lie close to the zero-effect line.

Since several controls for entropy balancing come from the establishment panel survey, this dataset has fewer establishment observations than the administrative dataset for STW information. In total, I can match 6,736 establishments. To make sure that the matched sample is still representative of all establishments in Germany, I reproduce the analysis with all establishments in Germany but with the drawback of fewer controls for the entropy balancing in Section B.3 in the appendix. The results show the same pattern of effects as in Figure 2.

[14] Figure B.1 shows the results of the continuous model from Equation (4) in Chapter 5 without EBCT.

Figure 2: Event study plot for GVC-related trade with China and STW (continuous treatment)



Note: All coefficients refer to February 2020. GVC-related trade index is standardized ($\mu = 0, \sigma = 1$). The standard errors for the 95 percent confidence intervals are clustered on the sector level. EBCT weights are calculated for GVC-related trade with China. Top and bottom 1 percent firms are trimmed in the model. Short-time work rates are calculated as the number of workers in short-time work in a given month over the employment level in June 2019.
Source: Federal Employment Agency, Statistics/Labour Market Reporting (2016), IAB Establishment Panel, IAB Establishment History Panel, Alipour/Falck/Schüller (2023) and OECD (2022); own calculations. ©IAB

To gain a deeper understanding of the economic meaning of the effects of GVC trade integration for Germany, the following back-of-the-envelope calculation is presented for the additional costs of STW. Table 2 shows additional information on the German labor market for the months in which the effect of GVC-related trade on STW, which can be seen in Figure 2, is positive and significantly different from zero. In May 2020 the number of workers in STW was around 5.7 million. In relation to all workers subject to social insurance contributions, these are 17 percent (Statistics of the Federal Employment Agency, 2024). The monthly standard deviations of the share of STW are presented in Column (4). The coefficients of Figure 2 are shown in Column (5).

Table 2: Additional information on the German labor market

Month	(1) Worker in STW	(2) Employment	(3) Share STW in Germany	(4) sd STW in sample	(5) Coefficients from model
May-20	5,714,840	33,328,050	0.171	0.314	0.255
Jun-20	4,452,280	33,322,950	0.134	0.265	0.269
Jul-20	3,305,890	33,233,140	0.099	0.272	0.266
Aug-20	2,537,050	33,482,210	0.076	0.251	0.193
Sep-20	2,229,430	33,791,870	0.066	0.22	0.171
Oct-20	2,020,650	33,862,040	0.06	0.204	0.134

Note: The table shows information for all months where the coefficients in Figure 2 are significantly different from zero at the 95 percent level (Further, the coefficients are listed in Table B.1 in the Appendix B.
Source: Employment statistic provided by the Federal Employment Agency; own calculations. ©IAB

With the information in Column (4) and (5) the monthly ceteris paribus effect of an increase of one standard deviation higher GVC-related trade with China on the share of STW can be calculated. For May, the effect is:

$$0.255 \times 0.314 = 0.080$$

This means that ceteris paribus establishments in industries with one standard deviation higher GVC-related trade with China show a roughly 8 percentage points (pp) higher share of STW in May 2020. If all establishments were one standard deviation more GVC-integrated with China, then the share of STW relative to all workers would increase from 17 percent to 25 percent in May 2020.
The increase in GVC-related trade with China by one standard deviation is equivalent to an increase of 11 pp and almost half the sample mean of 23 percent.[15] This is roughly comparable to what would happen if the *"other transport equipment"* sector ($GVC^{CHN} = 0.391$) was as involved in GVC-related trade with China as the *"computer, electronic and optical equipment"* sector ($GVC^{CHN} = 0.509$).[16] The corresponding effects for the other months are shown in Column (1) of Table 3. An increase in STW by 8 pp in Mai 2020 corresponds to 2,666,244 additional STW reports.

$$33,328,050 \times 0.080 = 2,666,244$$

For all months from May to October 2020, a one standard deviation increase in GVC-related trade with China would result in a total of around 11 million more STW reports (see Column (2) in Table 3.)

[15] The summary statistics can be found in Table A.2 in the Appendix.
[16] See Table A.5 in the appendix for the values for all sectors.

Table 3: Effects by an on standard deviation increase of GVC-related trade with China

Month	(1) Additional share STW	(2) Additional workers STW	(3) Additional wage payments	(4) Additional social security contributions payments
May-20	0.08	2,666,244	988,776,587	745,828,434
Jun-20	0.071	2,365,929	877,404,937	661,821,445
Jul-20	0.072	2,392,786	887,364,718	669,334,050
Aug-20	0.048	1,607,146	596,010,124	449,566,973
Sep-20	0.038	1,284,091	476,205,170	359,198,792
Oct-20	0.027	914,275	339,058,913	255,750,168
Sum		11,230,472	4,164,820,448	3,141,499,863

Note: The table shows the effects of a hypothetical increase of GVC-related exports with China of one standard deviation. One standard deviation is equal to 11 percent more GVC-related exports with China.
Source: Employment statistic provided by the Federal Employment Agency; own calculations. ©IAB

In 2020, in total, more than 22 billion euros was spent on state transfer payments for STW from which 12.5 billion euros was allocated to wage replacement benefits for cyclical STW and around 9.5 billion euros to social security contributions.[17] In addition, the total number of monthly cyclical STW reports for the year 2020 is 33,912,124. Assuming that each STW report has the same cost, each STW report would cost 650.73 euros. Thus, 370.85 euros is charged for wage substitution benefits and 279.73 euros is for social security contributions (Statistics of the Federal Employment Agency, 2024). Using the number of hypothetical additional STW reports and the cost of a report, it is possible to calculate the cost of a one standard deviation increase in GVC-related exports with China during the crisis: for May 2020 the additional government transfer payments for wage substitutions would be:

$$2,666,244 \times €370.85 = €988{,}776{,}587$$

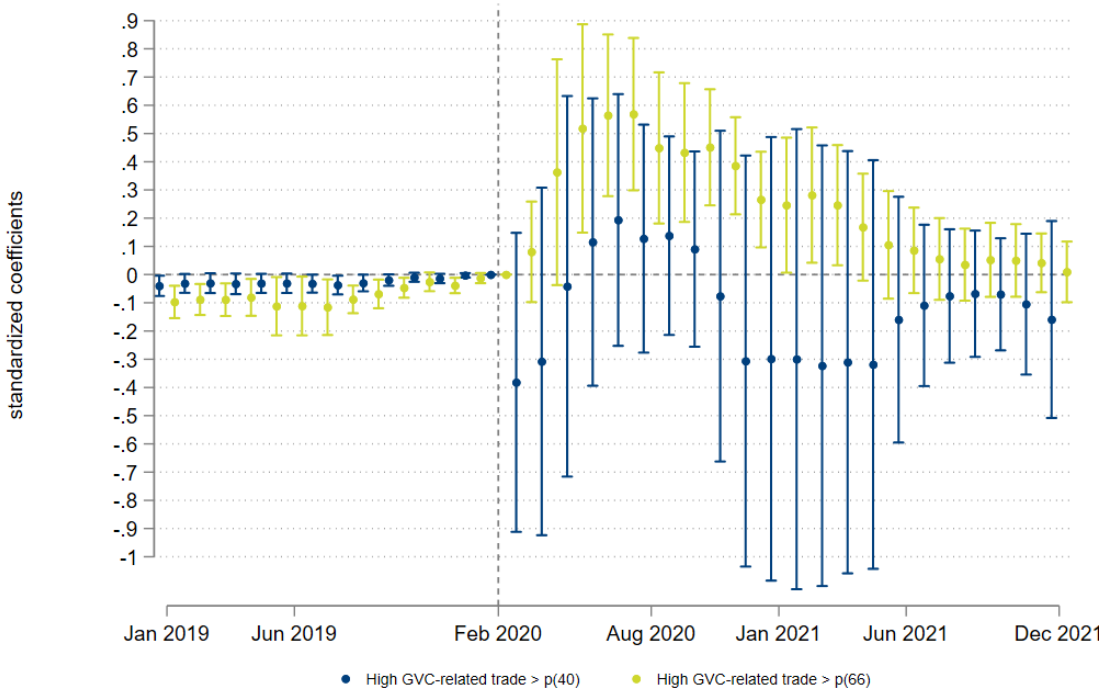
and government transfer payments for social security contributions would be:[18]

$$2,666,244 \times €279.73 = €745{,}828{,}434$$

In total across all months with significant coefficients, meaning from May to October 2020, the amount of hypothetical additional spending would be about 7.3 billion. This indicates that an increase of one standard deviation in GVC-related exports with China would lead to an additional expenditure of about 7.3 billion euros on STW, which is divided into approximately 4.2 billion euros for wage subsidies and 3.1 billion euros for social security contributions.

[17] The actual amount of social security contributions for cyclical STW is slightly lower since the number also includes the social security contribution for seasonal STW benefits.
[18] For the government transfer payments of the other months see Table 3.

Figure 3: Event study plot for GVC-related trade integration with China and STW (binary treatment)



Note: All coefficients are in reference to February 2020. GVC-related trade index is standardized ($\mu = 0, \sigma = 1$). The standard errors for the 95 percent confidence intervals are clustered on the industry level. It is not possible to use thresholds lower than the 40th percentile. The 40th percentile is the lowest threshold where convergence in the binary model is achieved. Short-time work rates are calculated as the number of workers in short-time work in a given month over the employment level in June 2019. The coefficients are estimated separately in two models.
Source: Federal Employment Agency, Statistics/Labour Market Reporting (2016), IAB Establishment Panel, IAB Establishment History Panel, Alipour/Falck/Schüller (2023) and OECD (2022); own calculations. ©IAB

Figure 3 depicts the results for the binary treatment specification described in Equation (3) in Section 5.1. In particular, it shows the binary variable equal to one for establishments that are above the 40th percentile of the GVC-related trade with China distribution[19] (blue line) and for establishments that are above the 66 percent percentile (green line).

In the pre-crisis period, all point estimates are almost identical and close to zero. In the crisis period, the point estimates for the 40th percentile specification show an alternating pattern around the zero effect line. In all months, the effects are not significantly different from zero. However, the pattern for the 66th percentile specification is different: Starting in March 2020, the point estimates increase and reach a peak between June and July 2020. Furthermore, the effects are significantly different from zero from May 2020 to March 2021. This pattern is similar to the continuous treatment specification in Figure 2. Comparing the

[19] It is not possible to use thresholds lower than the 40th percentile. The 40th percentile is the lowest threshold where convergence in the binary model is achieved.

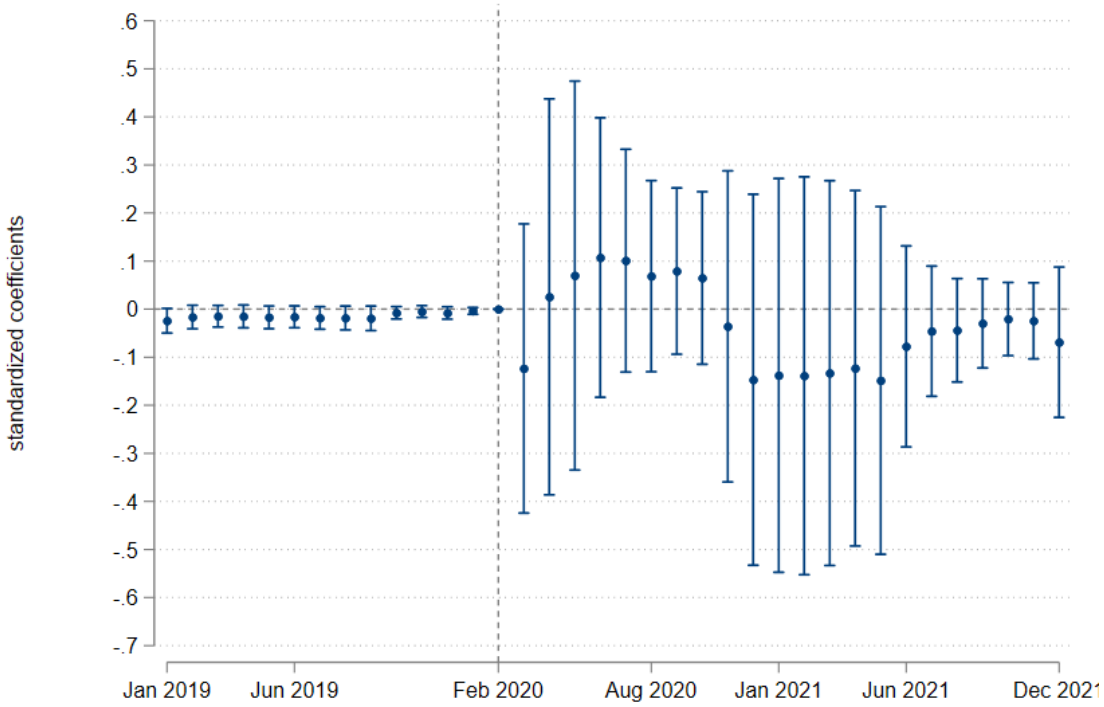
two binary specifications indicates that the point estimates of the 66th percentile specification are always higher than those of the 40th percentile specification. This is an important finding for the identification of the continuous specification because it supports the assumption that the relationship between GVC-related trade with China and STW is linear or at least monotonic, since a change in GVC-related trade with China should always have effects that go in the same direction (Callaway/Goodman-Bacon/Sant'Anna, 2024). All in all, the results suggest that the continuous and binary treatment specifications lead to comparable results.

6.2 Effects of worldwide GVC-related trade on STW

The reason for changing the treatment to worldwide GVC integration is to check whether GVC-related trade with China is just a proxy for GVC integration in general. Therefore, Figures 4 and 5 show the results of worldwide GVC-related trade excluding China in the continuous and binary treatment specification.
As in the previous section, the estimates for the pre-crisis period in the continuous specification do not suggest the presence of pre-crisis trends in Figure 4. In contrast to Figure 2, which shows the results for GVC-related trade with China, all confidence intervals intersect the zero effect line and the point estimates are smaller and often even negative in 2021.[20] It can be concluded that the increase in the continuous model with the world excluding China as a trading partner is weaker and imprecisely estimated compared to the results with China as a trading partner. This finding is consistent with the evidence provided by Lafrogne-Joussier/Martin/Mejean (2023). They show for French firms that exports and domestic sales decline more in the early phase of the pandemic when the trading partner is China compared to other countries.

[20] Figure B.2 in Appendix B shows the results of the continuous model from Equation (4) in Chapter 5 without EBCT.

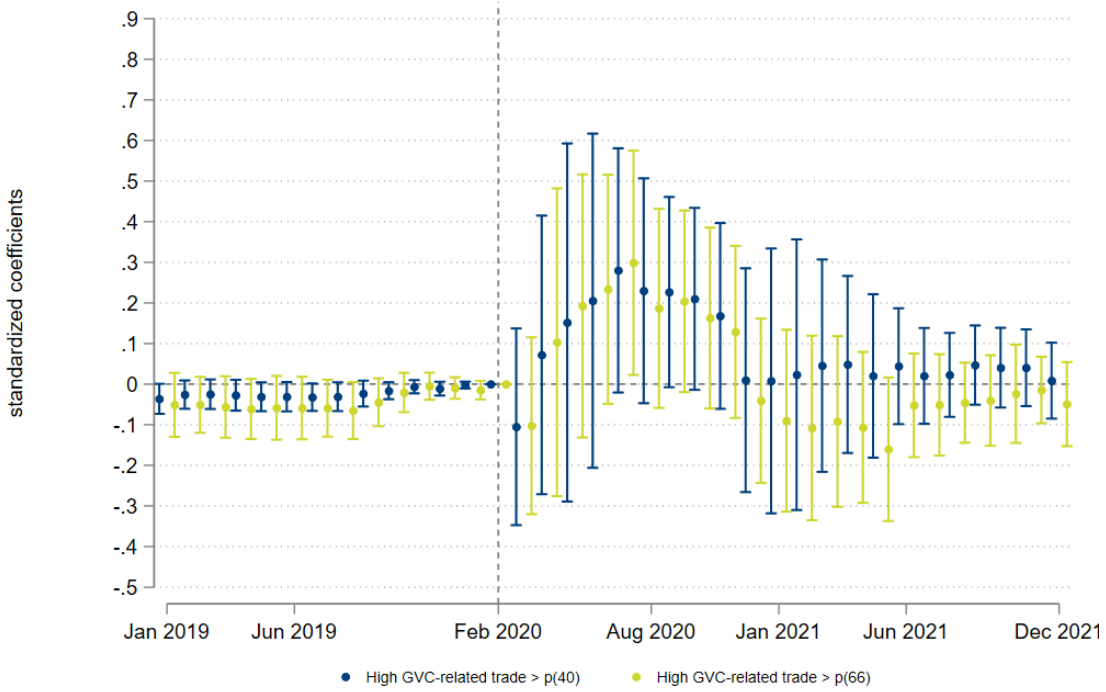
Figure 4: Event study plot for GVC-related trade with the world except China and STW (continuous treatment)



Note: : All coefficients are in reference to February 2020. GVC-related trade index is standardized ($\mu = 0, \sigma = 1$). The standard errors for the 95 percent confidence intervals are clustered on the firm level. EBCT weights are calculated for GVC integration with the worlds except China. Short-time work rates are calculated as the number of workers in short-time work in a given month over the employment level in June 2019.
Source: Federal Employment Agency, Statistics/Labour Market Reporting (2016), IAB Establishment Panel, IAB Establishment History Panel, Alipour/Falck/Schüller (2023) and OECD (2022); own calculations. ©IAB

The results of the binary treatment specification are presented in Figure 5. For both specifications, the 40th and the 66th percentile, there are no significant effects in the pre-crisis period and all point estimates are close to zero. At the beginning of the pandemic, the point estimates increased slightly for both specifications. However, the effects are not significant from zero except for the 66th percentile specification in July 2020. In general, the point estimates for both specifications do not differ much, in particular during the first stage of the pandemic and do not always increase in size from the 40th to the 66th specification. Accordingly, increasing the threshold for categorizing the control and treatment groups makes no difference to the effects on STW during the COVID-19 pandemic. This is different compared to the effects if the treatment is GVC-related trade with China. Likewise, the effects do not increase monotonically when the threshold is increased.

Figure 5: Event study plot for GVC-related trade integration with the world without China and STW (binary treatment)



Note: All coefficients are in reference to February 2020. GVC-related trade index is standardized ($\mu = 0, \sigma = 1$). The standard errors for the 95 percent confidence intervals are clustered on the industry level. Short-time work rates are calculated as the number of workers in short-time work in a given month over the employment level in June 2019. The coefficients are estimated separately in two models.
Source: Federal Employment Agency, Statistics/Labour Market Reporting (2016), IAB Establishment Panel, IAB Establishment History Panel, Alipour/Falck/Schüller (2023) and OECD (2022); own calculations. ©IAB

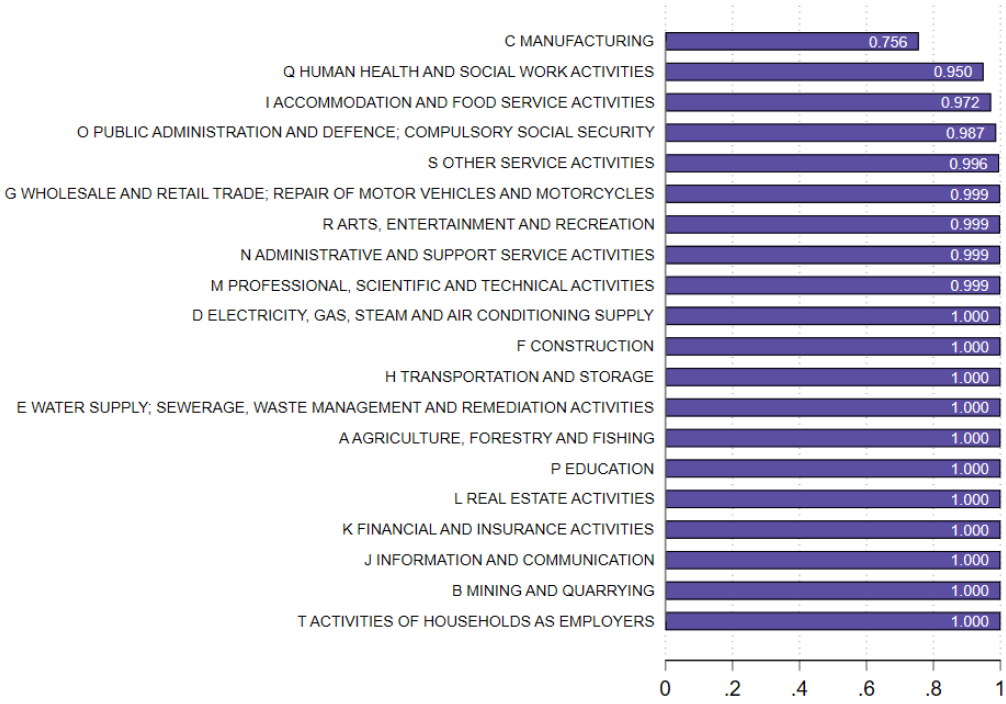
7 Mechanism and Robustness

7.1 Importance of specific industries

As shown in the previous chapter, GVC-related trade with China on average has a significant positive impact on STW. Since GVC-related trade of establishments is measured at the industry level, it could be that specific industries drive the aggregate effect. For this reason, I stepwise exclude establishments from one industry section (ISIC classification) and compare the results of the reduced sample with the results of the entire sample (Figure 2). Figure 6 displays the correlations between the point estimates for the entire sample and the point estimates without establishments in one industry for the months March 2020 until December 2021. The correlations indicate that the subsample without the manufacturing

sector (C) leads to a notable reduction in the correlation coefficient. This is interesting since Germany has a highly developed manufacturing sector and has become a key player in GVCs, particularly in high-tech industries such as automotive, chemical, and machinery (OECD, 2009).

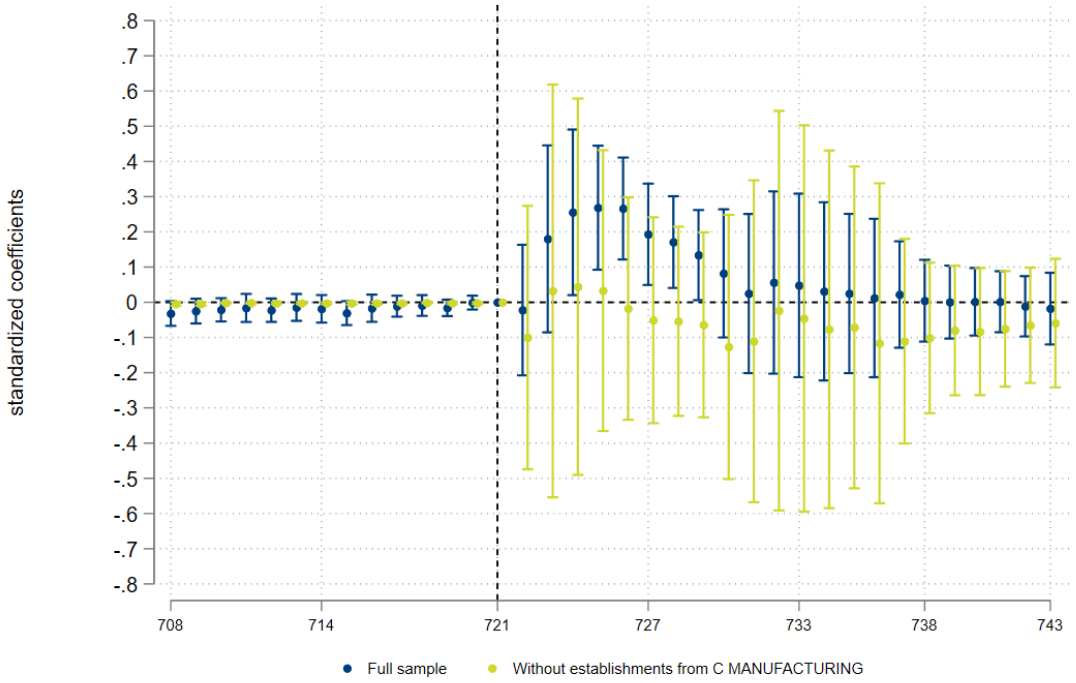
Figure 6: Correlations of effects from the full sample and effects without specific industries



Note: The figure shows the correlations between the coefficients in Figure 2 and the coefficients when the establishments of the 20 ISIC sections shown are excluded. The trade partner is China.
Source: IAB Establishment Panel, IAB Establishment History Panel, Alipour/Falck/Schüller (2023) and OECD (2022); own calculations. ©IAB

Since establishments in the manufacturing sector seem to be the main driver of the effect on STW, Figure 7 plots the effects for the full sample (blue) and for the reduced sample without the manufacturing establishments (green). The confidence intervals indicate that the effects of the two samples are not significantly different. However, without manufacturing, the point estimates in the first part of the pandemic are now close to zero and are not significantly different from zero. Carefully interpreted, these findings suggest that primarily the relatively high share of GVC-related trade with China of the manufacturing sector in Germany, seems to cause the overall effect in the first phase of the pandemic.

Figure 7: Effect with and without establishments from the manufacturing sector



Note: All coefficients are in reference to February 2020. GVC-related trade index is standardized ($\mu = 0, \sigma = 1$). The standard errors for the 95 percent confidence intervals are clustered on the industry level. Short-time work rates are calculated as the number of workers using short-time work in a given month over the employment level in June 2019.
Source: Employment statistic provided by the Federal Employment Agency and OECD (2022); own calculations.

7.2 Robustness checks

This section summarizes additional robustness checks that are described in more detail in Appendix B. To checks whether the mean imputation for the entropy balancing controls influences the results, Figure B.3 in Section A.2 shows the results for GVC-related trade with China on STW with and without mean imputation. It can be seen that the results are similar, so any influence of the mean imputation for entropy balancing controls can be ruled out. Despite the similar results, the imputation is chosen since it has the advantage that the slightly positive trend in 2019 disappears. In addition, the confidence intervals decrease on average due to a higher number of observations (establishments) in 2019 and parts of 2020. Section B.3 in the appendix shows that the sample of establishments used in the analysis is representative for all establishments in Germany. I reproduce the panel-event study for all establishments (N = 2,445,010) in Germany, but with a reduced number of explanatory variables for the entropy balancing. The results indicate that the sample used represents

the entire population of all establishments in a suitable way. Furthermore, Section B.4 shows the results for GVC-related trade on STW against a random treatment distribution. The results indicate that also for this "stricter" test, the results are significant for June and July 2020. Since the unit of observation in the dataset is the establishment, it is possible for a firm to have several establishments in different regions (multi-establishment firms). These firms tend to overreport STW because they may report STW for all their sub-firms (Kagerl/Schierholz/Fitzenberger, 2022). Chapter B.5 in the appendix shows that the effects without multi-establishment firms are almost identical.

7.3 GVC-related trade and supply problems for establishments

To learn more about the mechanism why establishments with high GVC-related trade with China used more short-time work during the first year of the pandemic, I use further information from the Establishment Panel (BP). The 2020 survey covers an additional section on the impact of the COVID-19 pandemic on establishments (Bellmann et al., 2022). Among others, it includes information on whether difficulties with the acquisition of inputs or with suppliers have a negative impact on the establishment during the pandemic in 2020.[21]

Together with information on GVC-related trade for sectors, I can estimate a model with a binary variable that indicates problems with the acquisition of inputs or with suppliers as the dependent variable.[22] The hypothesis is that, on average, establishments belonging to sectors that are more integrated in GVCs should have more problems with inputs and suppliers due to the breakdown of international trade during the crisis (see Lebastard/Matani/Serafini, 2023: for a comparable approach to firm exports).

The logistic model is given by:

$$Y_i = \beta_0 + \beta_1 GVC_{s(i)}^{ctry} + \sum_{k=2}^{K} \beta_k X_{ik} + \epsilon_i \tag{6}$$

where Y_i is the binary outcome for establishment i indicating whether establishments faces problems with the acquisition of inputs or with suppliers. The explanatory variable of

[21] The original question is (question 1b, option C): Which of the following negative impact did or does the Corona pandemic have on your establishment/office? - Pre-delivery difficulties of purchasing goods and services or difficulties with suppliers. For more information on the questionnaires, see https://fdz.iab.de/en/betriebsdaten/iab-establishment-panel-iab-bp-version-9321-v1/

[22] The question about pre-delivery difficulties of inputs or difficulties with suppliers was answered by 10,698 (74 percent) in 2020. When I match the question to the dataset described in Section A.1.1 I end up with 5,299 matched establishments (2,163 (41 percent) establishments affirmed the question, 3,136 (59 percent) did not).

interest is $GVC_{s(i)}^{ctry}$ which indicates the GVC-related trade of sectors s to which establishment i belongs and with a trade partner $ctry$ in the pre-crisis year 2019. Again, for $ctry$ I use China and the world without China. The white noise error term is ϵ_i.

Using the indicator as outcome has to be treated with caution: If establishments state that they had difficulties with inputs or suppliers, then this can be driven by problems at home and abroad. To control for potential problems at home, I add all control variables X_{ik} from the dataset used for the entropy balancing described in Section 3.2 to the model.[23] The estimated parameter for GVC-related trade should give a good approximation whether higher integrated establishments face more problems during the first year of the pandemic or not.

Table 4: GCV-related trade and problems with inputs and suppliers

	(1) OR/Std. error	(2) OR/Std. error	(3) OR/Std. error
GVC-related trade (China)	1.337***		1.593***
	(0.107)		(0.201)
GVC-related trade (world excluding China)		1.188**	0.820
		(0.087)	(0.106)
Constant	0.637***	0.649***	0.627***
	(0.056)	(0.058)	(0.051)
Controls	Yes	Yes	Yes
Observations	5298	5299	5298
Pseudo R^2	0.0415	0.0346	0.0432
Log likelihood	-3433.7	-3459.2	-3427.5

Note: The table shows the results of a logistic regression with odds ratios (OR). The outcome variable is a binary variable indicating the answer to question 1b option C of the IAB Establishment Panel 2020. It asks whether difficulties with the acquisition of inputs or with suppliers have negative impact on the establishment during the pandemic in 2020. Since industry 5, "Mining support service activities" shows no gross exports with China, the number of observations reduces from 5299 to 5298 in Model (1) and (3). The complete model with all control variables is shown in Table B.3. Significance levels: * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$ with clustered standard errors at the industry level.
Source: IAB Establishment Panel, IAB Establishment History Panel, Alipour/Falck/Schüller (2023) and OECD (2022); own calculations. ©IAB

Table 4 presents the results. Column (1) shows the effects of GVC-related trade with China on negative impact on establishment during the pandemic with respect to acquisition of inputs or with suppliers. The odds ratio of 1.337 implies that an establishment has a 33.7 percent higher chance of facing pre-delivery difficulties with goods or suppliers during the COVID-19 pandemic if its GVC-related trade with China increases by one standard deviation (equal to 11 percent).[24] The effect is significant at the 0.1 percent-level. For example, this means that

[23] Summary statistics of all variables are presented in Table A.4 in the Appendix A.
[24] GVC-related trade with China has a range from 0.054 until 0.65. This means that in the highest integrated sector, 65 percent of all exports from Germany to China are GVC-related.

an establishment in the *"Electrical equipment"* sector ceteris paribus has roughly a 34 percent greater chance of facing supply problems during the COVID-19 pandemic compared to an establishment equal in all observed characteristics but in the *"Electricity, gas, steam and air conditioning supply"* sector. The reason is that the *"Electrical equipment"* sector has a 10.4 percentage points, almost one standard deviation, higher GVC-related trade with China compared to the *"Electricity, gas, steam and air conditioning supply"* sector.

In Column (2), the odds ratio for the worldwide GVC-related trade except China is 1.188 and significant at the 5 percent significant level. In this context, an establishment now faces only an 18.8 percent greater chance of supply problems during the crisis compared to an establishment that is equal in all observed confounders but in an industry with a standard deviation (10.4 percent) lower GVC-related trade with the world except China. The finding that GVC-related trade with China, in contrast to the worldwide integration (except China), is more relevant to explain supply problems is also underlined by the model "quality": The pseudo-R^2 and the log-likelihood show that including GVC-related trade with China leads to a "better model" than GVC-related trade with the world excluding China. Column (3) presents both indices in a single model. It shows that the odd ratios are significantly different when controlled for each other. The effect of GVC-related trade with China is now even larger and still significant, but the effect for the world without China becomes smaller (even smaller than one) and is no longer significant.

The results indicate that during the COVID-19 pandemic, establishments in sectors that are more GVC-integrated with China have, on average, more difficulties with the acquisition of inputs or with suppliers. Thus, these problems may lead to production constraints during the crisis. One possible consequence of this would be an increased demand for short-time work for these establishments, which supports the results of Chapter 6.

8 Conclusion

This paper investigates the causal effect of GVC-related trade on short-time work during the COVID-19 crisis using a binary and continuous difference-in-differences approach combined with entropy balancing. Analyzing German establishment-level data on a monthly basis from January 2019 until December 2021 it is possible to observe the initial shock as well as the medium-time period of the pandemic. The results provide evidence that a one standard deviation higher GVC-related trade with China as a trading partner leads to an increase of up to almost 27 percentage points in the shares of short-time work. However, the effects are only significantly positive for May until October 2020 and decline already during the second

half of 2020. For months in which the effects are significant, an increase in one standard deviation in GVC-related trade with China would lead to an additional expenditure of about 7.3 billion euros on short-time work. In contrast to GVC-related trade with China, there is no significant relation between STW and worldwide (excluding China) GVC-related trade for German establishments during the pandemic.

An additional analysis of input supply problems of German establishment during the pandemic that makes use of survey data from the Establishment Panel supports the findings. The results indicate that in 2020, establishments that belong to sectors that are more GVC-integrated with China have on average more difficulties with the acquisition of inputs or with suppliers. Again, a higher worldwide (except China) GVC-integration shows no significant effects. Trade disruptions in GVCs, such as those that occurred at the onset of the pandemic, are not a one-time event. Russia's war against Ukraine and other growing geopolitical tensions are forcing companies and policymakers to continue to think about international supply chains. In this context, the findings of this paper support policy strategies to diversify GVCs. In the context of China, these strategies are commonly referred to in the media as *"decoupling from China"* or *"China plus one"* (The Economist, 2023). However, more research is needed to better measure the costs and benefits of GVCs and to assess specific strategies for robust GVCs.

References

Abowd, John M.; Kramarz, Francis; Margolis, David N. (1999): High Wage Workers and High Wage Firms. In: Econometrica : Journal of the Econometric Society, Vol. 67, No. 2, p. 251–333.

Alipour, Jean-Victor; Falck, Oliver; Schüller, Simone (2023): Germany's Capacities to Work from Home. In: European Economic Review, Vol. 151, No. 104354.

Alvarez, Isabel; Biurrun, Antonio; Martín, Victor (2022): The impact of COVID-19 on European global value chains: Some concerns about diversification and resilience. In: African Journal of Science, Technology, Innovation and Development, Vol. 14, No. 7, p. 1745–1760.

Angrist, Joshua D.; Imbens, Guido W.; Rubin, Donald B. (1996): Identification of Causal Effects Using Instrumental Variables. In: Journal of the American Statistical Association, Vol. 91, No. 434, p. 444–455.

Antràs, Pol; Chor, Davin (2013): Organizing the global value chain. In: Econometrica : Journal of the Econometric Society, Vol. 81, No. 6, p. 2127–2204.

Arriola, Christine; Guilloux-Nefussi, Sophie; Koh, Seung-Hee; Kowalski, Przemyslaw; Rusticelli, Elena; van Tongeren, Frank (2020): Efficiency and Risks in Global Value Chains in the Context of COVID-19. In: OECD Economics Department Working Papers, Vol. 1637.

Baldwin, Richard; Venables, Anthony J (2013): Spiders and Snakes: Offshoring and Agglomeration in the Global Economy. In: Journal of International Economics, Vol. 90, No. 2, p. 245–254.

Bartik, Alexander W.; Bertrand, Marianne; Cullen, Zoë B.; Glaeser, Edward L.; Luca, Michael; Stanton, Christopher T. (2020): How Are Small Businesses Adjusting to COVID-19? Early Evidence from a Survey. In: National Bureau of Economic Research Working Paper Series, Vol. No. 26989.

Bauer, Anja; Weber, Enzo (2021): COVID-19: How Much Unemployment Was Caused by the Shutdown in Germany? In: Applied Economics Letters, Vol. 28, No. 12, p. 1053–1058.

Bauernschuster, Stefan; Hener, Timo; Rainer, Helmut (2016): Children of a (Policy) Revolution: The Introduction of Universal Child Care and Its Effect on Fertility. In: Journal of the European Economic Association, Vol. 14, No. 4, p. 975–1005.

Baur, Andreas; Flach, Lisandra (2022): Deutsch-chinesische Handelsbeziehungen: Wie abhängig ist Deutschland vom Reich der Mitte? In: ifo Schnelldienst 4 / 2022.

Bellmann, Lisa; Brunner, Peter; Grunau, Philipp; Hohendanner, Christian; Kohaut, Susanne; Leber, Ute; Möller, Iris; Schwengler, Barbara; Stegmaier, Jens; Umkehrer, Matthias; Ellguth, Laura (2022): IAB Establishment Panel (IAB-BP) – Version 9321 V1.

Bellmann, Lisa; Lochner, Benjamin; Seth, Stefan; Wolter, Stefanie (2020): AKM Effects for German Labour Market Data. Report, Institut für Arbeitsmarkt- und Berufsforschung (IAB), Nürnberg [Institute for Employment Research, Nuremberg, Germany].

Belotti, Federico; Borin, Alessandro; Mancini, Michele (2020): ICIO: Stata Module for Economic Analysis with Inter-Country Input-Output Tables. Report, World Bank.

Bonadio, Barthélémy; Huo, Zhen; Levchenko, Andrei A; Pandalai-Nayar, Nitya (2021): Global Supply Chains in the Pandemic. In: Journal of International Economics, Vol. 133, p. 103 534.

Borin, Alessandro; Mancini, Michele (2019): Measuring What Matters in Global Value Chains and Value-Added Trade. Policy Research Working Paper Series 8804, The World Bank.

Borin, Alessandro; Mancini, Michele (2015): Follow the Value Added: Bilateral Gross Export Accounting. Report Bank of Italy Temi di Discussione (Working Paper) No. 1026, Bank of Italy, Economic Research and International Relations Area.

Borin, Alessandro; Mancini, Michele; Taglioni, Daria (2021): Measuring Exposure to Risk in Global Value Chains. Policy Research Working Paper Series 9785, The World Bank.

Brockmann, Dirk; Robert Koch Institute (2022): Covid-19 Mobility Project: Data and Methods. URL {https://www.covid-19-mobility.org/data-info/}, accessed: 2024-06-26.

Callaway, Brantly; Goodman-Bacon, Andrew; Sant'Anna, Pedro H. C (2024): Difference-in-differences with a Continuous Treatment. In: NBER Working Paper Series, No. 32117.

Card, David; Heining, Jörg; Kline, Patrick (2013): Workplace Heterogeneity and the Rise of West German Wage Inequality. In: The Quarterly Journal of Economics, Vol. 128, No. 3, p. 967–1015.

Destatis (2024): Glossar: Branchen und Unternehmen, Handwerk, Betrieb. URL https://www.destatis.de/DE/Themen/Branchen-Unternehmen/Handwerk/Glossar.

Ellguth, Peter; Kohaut, Susanne; Möller, Iris (2014): The IAB Establishment Panel—Methodological Essentials and Data Quality. In: Journal for Labour Market Research, Vol. 47, No. 1, p. 27–41.

Eppinger, Peter; Felbermayr, Gabriel J; Krebs, Oliver; Kukharskyy, Bohdan (2021): Decoupling Global Value Chains. Report CESifo Working Paper No. 9079, CESifo.

Ernst, Dieter; Kim, Linsu (2002): Global Production Networks, Knowledge Diffusion, and Local Capability Formation. In: Research Policy, Vol. 31, No. 8, p. 1417–1429.

Espitia, Alvaro; Mattoo, Aaditya; Rocha, Nadia; Ruta, Michele; Winkler, Deborah (2022): Pandemic Trade: COVID-19, Remote Work and Global Value Chains. In: The World Economy, Vol. 45, No. 2, p. 561–589.

Essletzbichler, J.; Pintar, N.; Grumiller, J.; Raza, W.; Grohs, H. (2021): Post Covid-19 Value Chains : Options for Reshoring Production Back to Europe in a Globalised Economy. Publications Office of the European Union.

European Central Bank (2023): Global production and supply chain risks: insights from a survey of leading companies. In: Economic Bulletin Issue 7, 2023.

Federal Employment Agency, Statistics/Labour Market Reporting (2021): Grundlagen: Methodenbericht – Realisierte Kurzarbeit: Korrektur des Merkmals Arbeitsausfall. Report, Statistik der Bundesagentur für Arbeit.

Federal Employment Agency, Statistics/Labour Market Reporting (2016): Statistik Über Kurzarbeit von Betrieben und Kurzarbeiter - Umstellung der Datenbasis und der statistischen Methode (aktualisierte Fassung). Report, Statistik der Bundesagentur für Arbeit.

Felbermayr, Gabriel; Hinz, Julian; Chowdhry, Sonali (2021): Après-ski: The spread of coronavirus from Ischgl through Germany. In: German Economic Review, Vol. 22, No. 4, p. 415–446.

Fischer, Gabriele; Janik, Florian; Müller, Dana; Schmucker, Alexandra (2009): The IAB Establishment Panel - Things Users Should Know: Schmollers Jahrbuch. In: Schmollers Jahrbuch, Vol. 129, No. 1, p. 133–148.

Ganzer, Andreas; Schmucker, Jens; Wolter, Alexandra, Stefanie; Stegmaier (2022): Establishment History Panel 1975–2021 (BHP 7521 V1).

Gensicke, Miriam; Tschersich, Nikolai; Kohaut, Susanne; Mielewczyk, Christina; Künzel, Sophie (2022): Technical Report on the IAB Establishment Panel - Wave 29 (2021). Report, Institut für Arbeitsmarkt- und Berufsforschung (IAB).

Gereffi, Gary; Humphrey, John; Sturgeon, Timothy (2005): The Governance of Global Value Chains. In: Review of International Political Economy, Vol. 12, No. 1, p. 78–104.

Gerschel, Elie; Martinez, Alejandra; Mejean, Isabelle (2020): Propagation of Shocks in Global Value Chains: The Coronavirus Case. Report, Institut des Politiques Publiques (IPP).

Hainmueller, Jens (2012): Entropy Balancing for Causal Effects: A Multivariate Reweighting Method to Produce Balanced Samples in Observational Studies. In: Political Analysis, Vol. 20, No. 1, p. 25–46.

Hummels, David; Ishii, Jun; Yi, Kei-Mu (2001): The Nature and Growth of Vertical Specialization in World Trade. In: Journal of International Economics, Vol. 54, No. 1, p. 75–96.

Imbens, Guido W. (2004): Nonparametric Estimation of Average Treatment Effects under Exogeneity: A Review. In: The Review of Economics and Statistics, Vol. 86, No. 1, p. 4–29.

International Monetary Fund (2022): Chapter 4. Global Trade and Value Chains during the Pandemic. In: World Economic Outlook: War Sets Back the Global Recovery.

Kagerl, Christian; Schierholz, Malte; Fitzenberger, Bernd (2022): Later one knows better: the over-reporting of short-time work in firm surveys. In: Journal for Labour Market Research, Vol. 56, No. 1, p. 1–19.

Kejžar, Katja Zajc; Velić, Alan; Damijan, Jože P. (2022): COVID-19, Trade Collapse and GVC Linkages: European Experience. In: The World Economy, p. 1–32.

Kim, Ayoung; Lim, Jaewon; Colletta, Aaron (2022): How Regional Economic Structure Matters in the Era of COVID-19: Resilience Capacity of U.S. States. In: The Annals of Regional Science.

Koopman, Robert; Wang, Zhi; Wei, Shang-Jin (2014): Tracing Value-Added and Double Counting in Gross Exports. In: American Economic Review, Vol. 104, No. 2, p. 459–94.

Lafrogne-Joussier, Raphael; Martin, Julien; Mejean, Isabelle (2023): Supply shocks in supply chains: Evidence from the early lockdown in China. In: IMF economic review, Vol. 71, No. 1, p. 170–215.

Lebastard, Laura; Matani, Marco; Serafini, Roberta (2023): GVC exporter performance during the COVID-19 pandemic: the role of supply bottlenecks. In: ECB Working Paper No. 2766.

Meier, Matthias; Pinto, Eugenio (2020): Covid-19 Supply Chain Disruptions. In: Covid Economics, Vol. 48, p. 139–170.

Meinen, Philipp; Serafini, Roberta; Papagalli, Ottavia (2021): Regional economic impact of Covid-19: The role of sectoral structure and trade linkages. In: ECB Working Paper No. 2528.

Nagengast, Arne; Stehrer, Robert (2016): Accounting for the Differences between Gross and Value Added Trade Balances. In: The World Economy, Vol. 39, No. 9, p. 1276–1306.

Naujoks, Tabea; Kreyenfeld, Michaela; Dummert, Sandra (2022): The Division of Child Care during the Coronavirus Crisis in Germany: How Did Short-Time Work Affect Fathers' Engagement? In: Journal of Family Research, Vol. 34, No. 1.

OECD (2023): Trade in Goods and Services (Indicator). URL https://data.oecd.org/trade/trade-in-goods-and-services.htm.

OECD (2022): OECD Inter-Country Input-Output Database. URL http://oe.cd/icio.

OECD (2009): Global Value Chains (GVCs): Germany. URL https://search.oecd.org/sti/ind/GVCs%20-%20GERMANY.pdf.

Partridge, Mark; Chung, Seung-hun; Wertz, Sydney Schreiner (2022): Lessons from the 2020 Covid Recession for Understanding Regional Resilience. In: Journal of Regional Science, Vol. 62, No. 4, p. 1006–1031.

Rubin, Donald B. (1980): Randomization Analysis of Experimental Data: The Fisher Randomization Test Comment. In: Journal of the American Statistical Association, Vol. 75, No. 371, p. 591–593, URL http://www.jstor.org/stable/2287653.

Statistics of the Federal Employment Agency (2024): Short-term work. URL https://statistik.arbeitsagentur.de/DE/.

The Economist (2023): Attempts to make supply chains resilient are likely to fail. In: Special report – Demand for supplies.

The Economist (2020): Has covid-19 killed globalisation? – The flow of people, trade and capital will be slowed. In: Goodbye Globalization – The dangerous lure of self-sufficency.

Tübbicke, Stefan (2021): Entropy Balancing for Continuous Treatments. In: Journal of Econometric Methods, Vol. 11, No. 1, p. 71–89.

World Bank (2024): WITS World Integrated Trade Solution. URL https://wits.worldbank.org/gvc/global-value-chains.html.

World Bank (2020): World Development Report 2020: Trading for Development in the Age of Global Value Chains. Report, URL https://www.worldbank.org/en/publication/wdr2020.

Appendix A

A.1 Sample restrictions

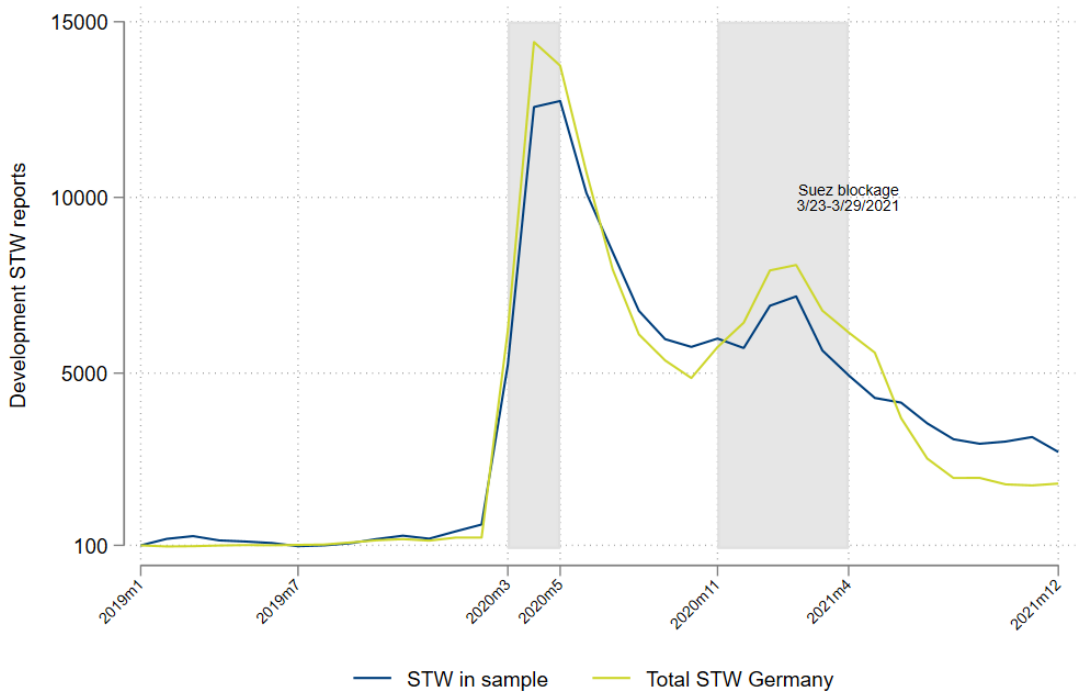
A.1.1 Dataset for the entropy balancing

- The Establishment History Panel (BHP) provides information on 3,069,299 establishments in 2019 with in total 38,780,805 employees.
- The Establishment Panel (BP) offers 19,501 unique establishment information in 2019.
- After linking the BP and the BHP via an unique identifier, I end up with 13,827 establishments in the year 2019.
- For the analysis, I only consider establishments which are observed from 2019 until 2021.
- 35 establishments are dropped since they switch the industry categorization within the three years.
- I end up with 6,736 establishments which I can observe over all three years and have a unique industry categorization.
- For the year 2019, the average establishment has 72 employees. The smallest establishment has one employee and the largest has 12,313 employees.

A.1.2 Monthly panel dataset from January 2019 until December 2021

- The number of establishments with at least one valid short-time work application from January 2019 until December 2021 in the dataset is 783,429.
- For 6,736 establishments I can find a match with the survey data from the BP.
- In the panel, I have 242,496 month-establishment observations from January 2019 until December 2021.
- Figure A.1 shows the development of STW within the sample and the entire population in Germany over the three observed years.

Figure A.1: Development of short-time work in the sample an the entire population of establishments between January 2019 and December 2021



Note: The blue line indicates the development of the number of accepted STW applications from the 6,736 firms in the sample, the green line indicates the development for the total population. January 2019 serves as the reference (set to 100). The gray bars indicate the lockdown periods in Germany.
Source: IAB Establishment Panel and Federal Employment Agency, Statistics/Labour Market Reporting (2016), own calculations. ©IAB

A.2 Imputation for control variables

Some explanatory variables have missing values. This is particularly the case for the proportion of intermediate consumption in turnover and the development of business volume from the current year to the previous year in the IAB Establishment Panel. For more information, see Table 5 in Gensicke et al. (2022). For the entropy balancing, each observation with missing values is neglected. As a consequence, it is not possible to calculate the weights of these observations. It could be that the relatively large amount of missing observations in single variables might lead to a biased and non-representative sample. To keep the information, I impute the missing information with the sample mean. The replacement of the missing observation with the sample mean of the corresponding variable means that the number of observation is not excluded, but the variable also does not contribute to the calculation of the weight. Table A.1 shows the number of observations before and after the imputation. For all variables, the mean is rather constant, which implies that there should be no potential bias because of the imputation.
Furthermore, Figure B.3 in the appendix shows the results that correspond to Figure 2 without mean imputation.

Table A.1: Means before and after imputation

	N	N_imp	Mean	Mean_imp
Prop. intermed. consump. of turnover(in %)	4095	6736	46.581	46.353
Prop. business volume abroad (in %)	5278	6736	6.197	6.154
Share low-skilled workers	6691	6736	.097	.097
Share medium-skilled workers	6691	6736	.743	.743
Share high-skilled workers	6691	6736	.161	.161
Daily wage p(25)	5677	6736	87.091	87.041
Daily wage p(50)	5677	6736	97.448	97.41
Daily wage p(75)	5677	6736	111.714	111.741
AKM firm-effects 2010-2017	4331	6736	.206	.206

Note: Number of observations and means before and after imputation.
Source: IAB Establishment Panel, IAB Establishment History Panel; own calculations. ©IAB

A.3 Summary statistics

Table A.2: Summary statistics for the monthly panel

	N	Min	Mean	Median	Max	SD
Share of short-time work	237600	0	0.047	0	16	0.19
GVC trade with CHN in share of GEXP	237600	0.054	0.23	0.25	0.65	0.11
GVC trade with WLD without CHN in share of GEXP	237600	0.089	0.32	0.35	0.75	0.13
COVID-19 infections	237600	0	32.0	1.44	1797.5	126.2
Stringency index	237600	0	25.9	30.7	66.7	22.7
Regional mobility	237600	-0.57	-0.014	0	1.33	0.14

Note: The share of short-time work (STW) is calculated as the number of STW in the current month divided by the number of all workers in June 2019. The COVID-19 infections, the stringency index and the regional mobility are assigned to the establishments by the labor market region of their residence.
Source: Federal Employment Agency, Statistics/Labour Market Reporting (2016), Corona Datenplatform and Brockmann/Robert Koch Institute (2022); own calculations. ©IAB

Table A.3: Summary statistics to predict GVC integration with entropy balancing in 2019

	N	Min	Mean	Median	Max	SD
Share medium-skilled workers	6736	0	0.74	0.80	1	0.25
Share high-skilled workers	6736	0	0.16	0.073	1	0.23
Share STEM occupations	6736	0	0.016	0	1	0.072
Share professions with university degree	6736	0	0.016	0	1	0.074
Share employees in highly complex tasks	6736	0	0.098	0.0056	1	0.19
Share managers	6736	0	0.043	0	1	0.13
Daily wage p(25)	6736	3.55	87.0	86.8	893.7	32.2
Daily wage p(50)	6736	3.55	97.4	97.2	1270.3	39.3
Daily wage p(75)	6736	3.55	111.7	111.9	1647.0	50.4
AKM firm-effects 2010-2017	6736	-1.81	0.21	0.21	1.86	0.21
Prop intermed. consump. of turnover(in %)	6736	1	46.4	46	99	17.4
Prop. business volume abroad (in %)	6736	0	6.15	0	100	15.0
WfH Capacity	6736	0.30	0.55	0.54	0.89	0.13
Loss of value added	6736	-1	-0.22	-0.065	0	0.27
Distance to Bergamo (km)	6736	200.6	663.2	670.3	1025.4	187.5

Note: Missing values in the observations are mean value imputed. See Section A.2 for further information.
Source: Federal Employment Agency, Statistics/Labour Market Reporting (2016), Alipour/Falck/Schüller (2023) and OECD (2022); own calculations. ©IAB

Table A.4: Summary statistics for establishments and supply problems

	N	Min	Mean	Median	Max	SD
Pandemic Impacts: Problems supply chains and int. goods	5299	0	0.41	0	1	0.49
GVC CHN in share of GEXP	5298	0.054	0.24	0.25	0.65	0.11
GVC WLD in share of GEXP	5299	0.089	0.31	0.32	0.74	0.14
Number of employees	5299	1	87.0	16	44686	670.5
Share low-skilled workers	5299	0	0.11	0.053	1	0.17
Share medium-skilled workers	5299	0	0.74	0.79	1	0.25
Share high-skilled workers	5299	0	0.15	0.070	1	0.22
Share STEM occupations	5299	0	0.015	0	1	0.068
Share professions with university degree	5299	0	0.013	0	1	0.068
Share employees in highly complex tasks	5299	0	0.088	0.0034	1	0.17
Share managers	5299	0	0.031	0	1	0.095
Daily wage p(25)	5299	6.08	85.2	86.8	569.9	30.7
Daily wage p(50)	5299	6.08	95.6	97.2	681.3	37.1
Daily wage p(75)	5299	6.08	110.3	111.9	872.0	48.0
WfH Capacity	5299	0.30	0.54	0.54	0.89	0.12
Loss of value added	5299	-1	-0.25	-0.069	0	0.29
Distance to Bergamo (km)	5299	197.4	655.7	666.9	1025.4	190.1
Prop. intermed. consump. of turnover(in %)	5299	1	46.7	46	99	18.0
Prop. business volume abroad (in %)	5299	0	7.00	0	100	16.7
AKM firm-effects 2010-2017	5299	-1.81	0.20	0.21	1.73	0.22

Note: Missing values in the observations are mean value imputed. See Section A.2 for further information.
Source: Federal Employment Agency, Statistics/Labour Market Reporting (2016), IAB Establishment Panel, IAB Establishment History Panel, Alipour/Falck/Schüller (2023), OECD (2022) and World Bank (2024); own calculations. ©IAB

Table A.5: Indices for GVC-related trade by industry

	GVC^{WLD}	GVC^{CHN}
Agriculture, hunting, forestry	0.404	0.307
Fishing and aquaculture	0.541	0.271
Mining and quarrying, energy producing products	0.609	0.485
Mining and quarrying, non-energy producing products	0.513	0.239
Mining support service activities	0.557	.
Food products, beverages and tobacco	0.347	0.313
Textiles, textile products, leather and footwear	0.397	0.480
Wood and products of wood and cork	0.447	0.395
Paper products and printing	0.496	0.389
Coke and refined petroleum products	0.716	0.654
Chemical and chemical products	0.574	0.482
Pharmaceuticals, medicinal chemical and botanical products	0.309	0.254
Rubber and plastics products	0.547	0.464
Other non-metallic mineral products	0.396	0.313
Basic metals	0.741	0.598
Fabricated metal products	0.502	0.354
Computer, electronic and optical equipment	0.443	0.509
Electrical equipment	0.457	0.412
Machinery and equipment, nec	0.415	0.364
Motor vehicles, trailers and semi-trailers	0.438	0.346
Other transport equipment	0.481	0.391
Manufacturing nec; repair and installation of machinery and equipment	0.371	0.333
Electricity, gas, steam and air conditioning supply	0.440	0.308
Water supply; sewerage, waste management and remediation activities	0.377	0.271
Construction	0.392	0.283
Wholesale and retail trade; repair of motor vehicles	0.311	0.256
Land transport and transport via pipelines	0.358	0.280
Water transport	0.541	0.439
Air transport	0.404	0.349
Warehousing and support activities for transportation	0.461	0.311
Postal and courier activities	0.476	0.195
Accommodation and food service activities	0.144	0.143
Publishing, audiovisual and broadcasting activities	0.310	0.177
Telecommunications	0.290	0.184
IT and other information services	0.324	0.223
Financial and insurance activities	0.448	0.187
Real estate activities	0.0889	0.0790
Professional, scientific and technical activities	0.345	0.174
Administrative and support services	0.414	0.190
Public administration and defence; compulsory social security	0.192	0.124
Education	0.0996	0.0536
Human health and social work activities	0.159	0.138
Arts, entertainment and recreation	0.138	0.110
Other service activities	0.130	0.113

Note: Values can be interpreted as the share of exports that is GVC-related in relation to the total export of the industry. The derivation and an explanation of the indices can be found in Section 4. No values are available for the sector "D98: Activities of households as employers; undifferentiated goods- and services-producing activities of households for own use".
Source: OECD (2022); own calculations. ©IAB

Appendix B

B.1 Additional regression results

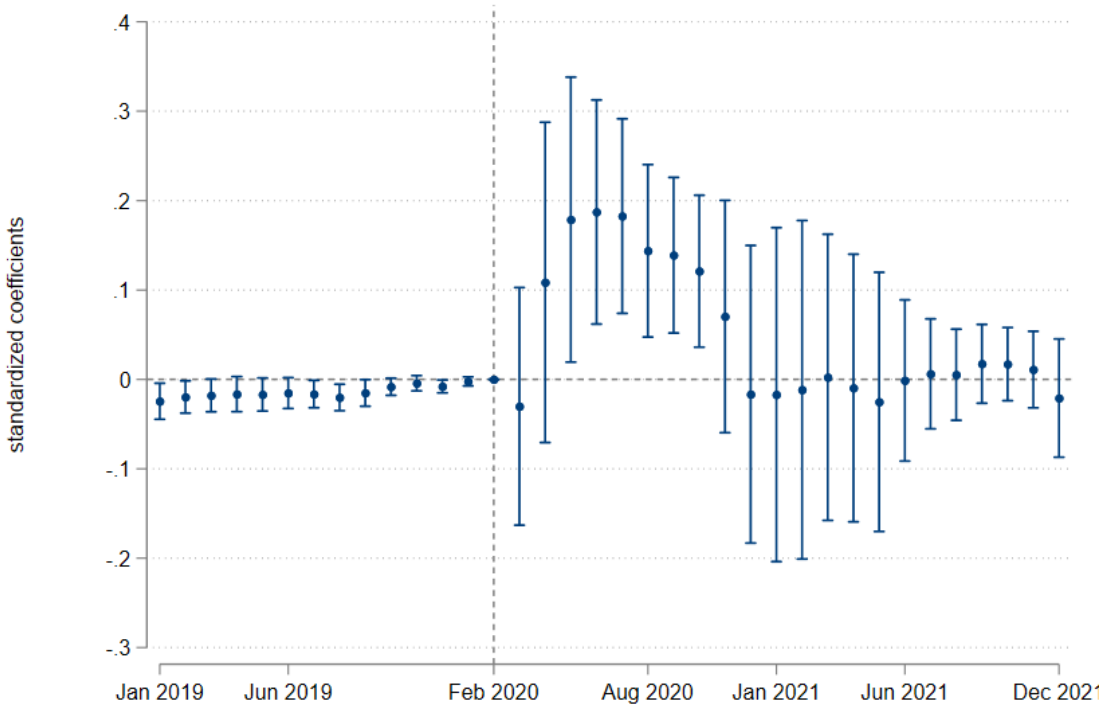
Table B.1: Coefficients from panel event study plot for GVC-related trade with China

Month	Beta coefficient	95% confidence interval	
Jan-19	-0.032	-0.067	0.003
Feb-19	-0.025	-0.060	0.010
Mar-19	-0.021	-0.054	0.012
Apr-19	-0.016	-0.056	0.024
May-19	-0.022	-0.056	0.011
Jun-19	-0.015	-0.053	0.023
Jul-19	-0.019	-0.058	0.020
Aug-19	-0.031	-0.065	0.003
Sep-19	-0.017	-0.055	0.022
Oct-19	-0.011	-0.041	0.019
Nov-19	-0.009	-0.039	0.020
Dec-19	-0.016	-0.039	0.007
Jan-20	-0.001	-0.021	0.019
Feb-20	ref.		
Mar-20	-0.022	-0.208	0.163
Apr-20	0.180	-0.085	0.446
May-20	0.255	0.020	0.491
Jun-20	0.269	0.092	0.445
Jul-20	0.266	0.122	0.411
Aug-20	0.193	0.049	0.337
Sep-20	0.171	0.041	0.301
Oct-20	0.134	0.006	0.262
Nov-20	0.082	-0.100	0.264
Dec-20	0.025	-0.201	0.251
Jan-21	0.056	-0.203	0.315
Feb-21	0.048	-0.213	0.308
Mar-21	0.031	-0.222	0.284
Apr-21	0.025	-0.201	0.251
May-21	0.012	-0.213	0.237
Jun-21	0.022	-0.129	0.173
Jul-21	0.004	-0.112	0.121
Aug-21	0.001	-0.103	0.104
Sep-21	0.001	-0.094	0.097
Oct-21	0.002	-0.085	0.088
Nov-21	-0.011	-0.097	0.074
Dec-21	-0.018	-0.120	0.084

Note: All coefficients are in reference to February 2020. GVC-related trade index is standardized ($\mu = 0, \sigma = 1$). The standard errors for the 95 percent confidence intervals are clustered on the firm level. EBCT weights are calculated for GVC-related trade with China. Top and bottom 1 percent firms are trimmed in the model. Short-time work rates are calculated as the number of workers in short-time work in a given month over the employment level in June 2019.

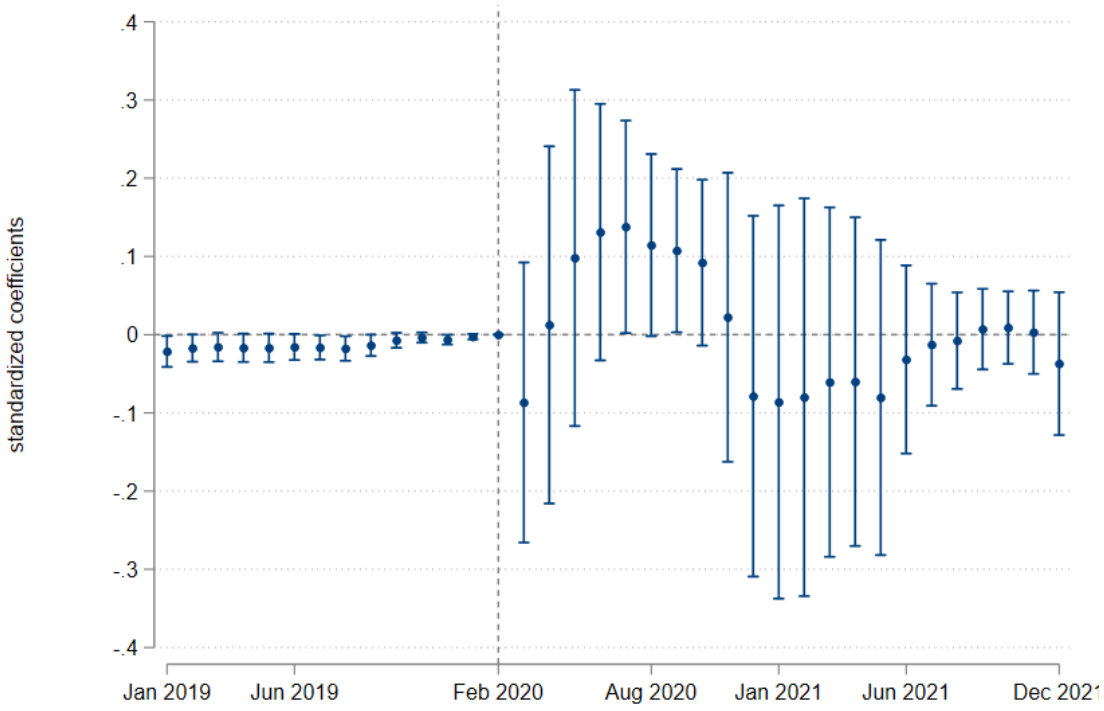
Source: Federal Employment Agency, Statistics/Labour Market Reporting (2016), IAB Establishment Panel, IAB Establishment History Panel, Alipour/Falck/Schüller (2023) and OECD (2022); own calculations. ©IAB

Figure B.1: Baseline event study plot for GVC-related trade with China and STW (continuous treatment)



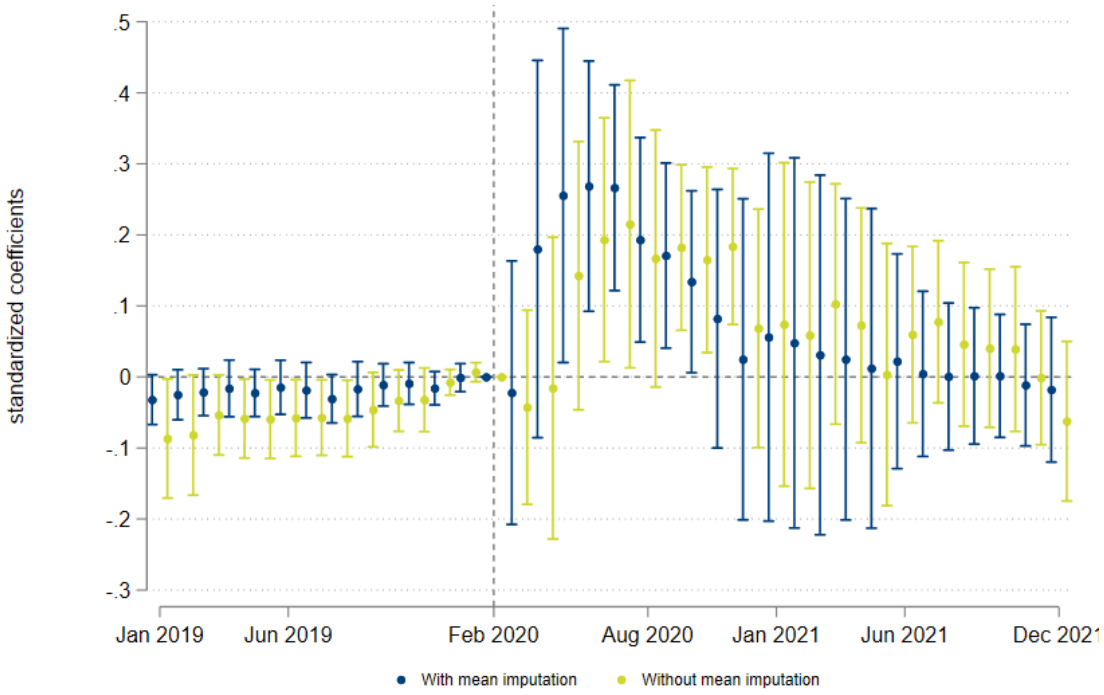
Note: All coefficients are in reference to February 2020. GVC-related trade index is standardized ($\mu = 0, \sigma = 1$). The standard errors for the 95 percent confidence intervals are clustered on the industry level. Short-time work rates are calculated as the number of workers in short-time work in a given month over the employment level in June 2019.
Source: Federal Employment Agency, Statistics/Labour Market Reporting (2016) and OECD (2022); own calculations. ©IAB

Figure B.2: Baseline event study plot for GVC-related trade with the world without China and STW (continuous treatment)



Note: All coefficients are in reference to February 2020. GVC-related trade index is standardized ($\mu = 0, \sigma = 1$). The standard errors for the 95 percent confidence intervals are clustered on the firm level. Short-time work rates are calculated as the number of workers in short-time work in a given month over the employment level in June 2019.
Source: Federal Employment Agency, Statistics/Labour Market Reporting (2016) and OECD (2022); own calculations. ©IAB

Figure B.3: Event study plot with and without mean imputation for GVC-related trade with China and STW (continuous treatment)



Note: The blue line indicates the coefficients with mean imputation, and the green line without mean imputation. For further details on the imputation, see Section A.2 in the appendix. All coefficients are in reference to February 2020. GVC-related trade index is standardized ($\mu = 0, \sigma = 1$). The standard errors for the 95 percent confidence intervals are clustered on the firm level. Short-time work rates are calculated as the number of workers in short-time work in a given month over the employment level in June 2019.
Source: Federal Employment Agency, Statistics/Labour Market Reporting (2016), IAB Establishment Panel, IAB Establishment History Panel, Alipour/Falck/Schüller (2023) and OECD (2022); own calculations. ©IAB

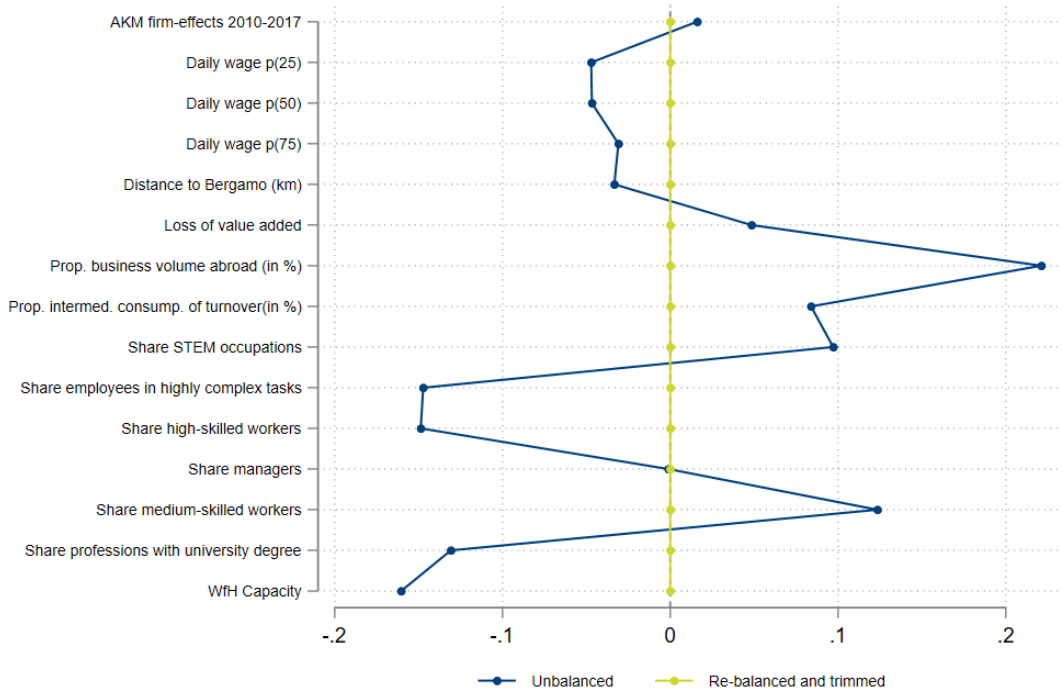
B.2 Additional entropy balancing results

Table B.2: Balancing table for GVC-related trade with the world without China (binary treatment)

	Mean differences			
	Pre p(40)	Post p(40)	Pre p(66)	Post p(66)
AKM firm-effects 2010-2017	-0.474	-0.000	-0.355	-0.000
Daily wage p(25)	-0.180	-0.000	-0.156	-0.000
Daily wage p(50)	-0.231	-0.000	-0.194	-0.000
Daily wage p(75)	-0.284	-0.000	-0.229	-0.000
Distance to Bergamo (km)	-0.009	0.000	-0.005	0.000
Loss of value added	0.101	0.000	0.520	0.000
Prop. business volume abroad (in %)	0.474	0.000	0.654	0.000
Prop. intermed. consump. of turnover(in %)	-0.017	0.000	0.013	0.000
Share STEM occupations	0.634	0.000	0.131	0.000
Share employees in highly complex tasks	-1.235	-0.000	-1.667	-0.000
Share high-skilled workers	-0.728	-0.000	-0.923	-0.000
Share managers	0.184	0.000	-0.332	-0.000
Share medium-skilled workers	0.131	0.000	0.144	0.000
Share professions with university degree	-7.731	-0.000	-18.989	-0.002
WfH Capacity	-0.136	0.000	-0.037	-0.000

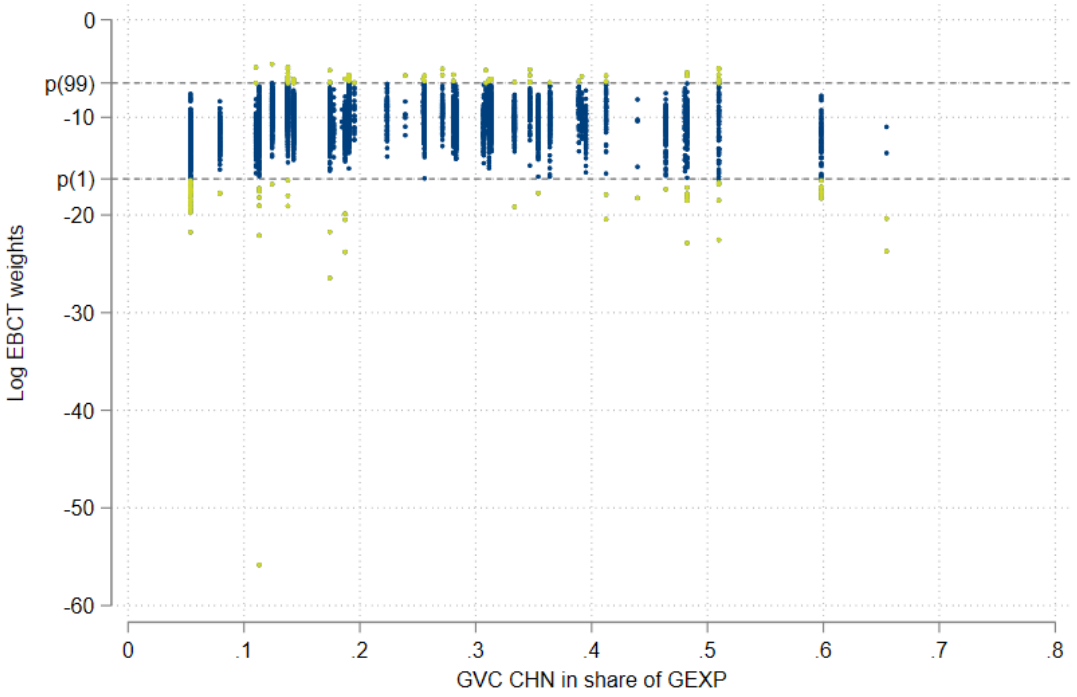
Note: The table shows the differences of the first moment (mean) between the treatment and the control group before and after entropy balancing. The first two columns show the differences when the treatment group is defined as GVC-related trade larger than the 40th percentile. Column three and four show the differences when the treatment group is defined as GVC-related trade larger than the 66th percentile.
Source: IAB Establishment Panel, IAB Establishment History Panel, Alipour/Falck/Schüller (2023) and OECD (2022); own calculations. ©IAB

Figure B.4: Correlations before and after entropy balancing for trade integration with the world without China



Note: The weighted correlations are shown after dropping the 1 percent smallest and largest firms regarding their weights. Further summary statistics of the variables are listed in Table A.3.
Source: IAB Establishment Panel, IAB Establishment History Panel, Alipour/Falck/Schüller (2023) and OECD (2022); own calculations. ©IAB

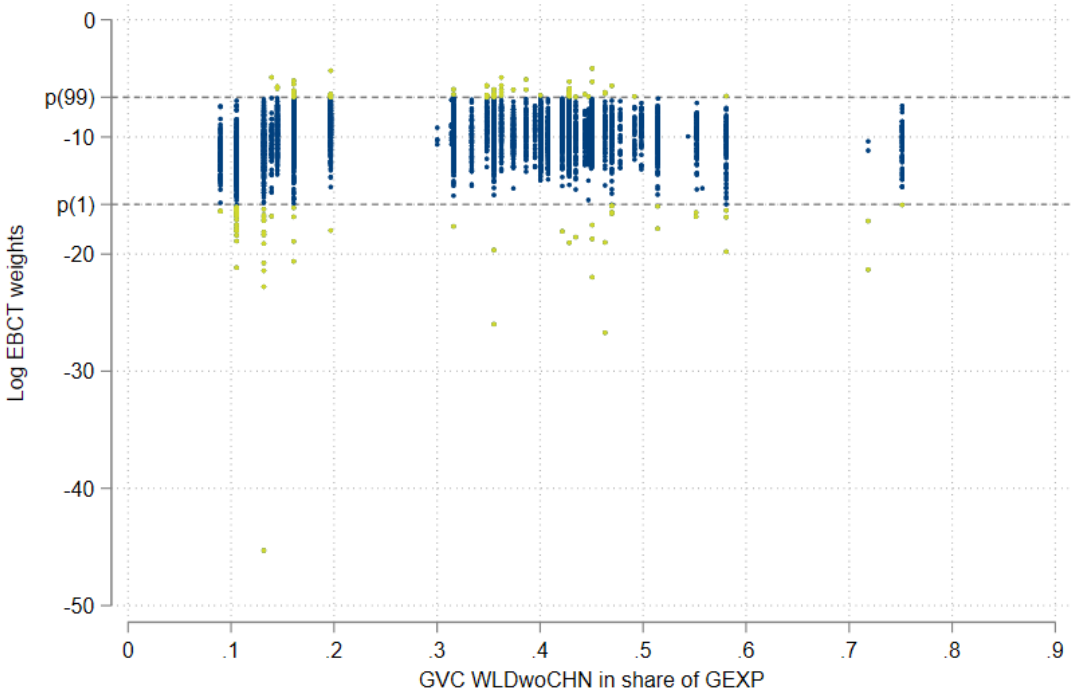
Figure B.5: Entropy balancing weights for trade integration with China



Note: Firms are ordered by their GVC-related trade with China. Each dot represents the weight generated by EBCT with the variables presented in Table A.3 and for GVC-related trade with China as treatment variable. The green dots are the 1 percent smallest and largest firm-level weights which are trimmed in the following to guarantee common support.

Source: IAB Establishment Panel, IAB Establishment History Panel, Alipour/Falck/Schüller (2023) and OECD (2022); own calculations. ©IAB

Figure B.6: Entropy balancing weights for GVC-related trade with the world without China



Note: Firms are ordered by their GVC-related trade with the world without China. Each dot represents the weight generated by EBCT with the variables presented in Table A.3 and for GVC-related trade with thw world without China as treatment variable. The green dots are the 1 percent smallest and largest firm-level weights which are trimmed in the following to guarantee common support.
Source: IAB Establishment Panel, IAB Establishment History Panel, Alipour/Falck/Schüller (2023) and OECD (2022); own calculations. ©IAB

B.3 Representability of the matched sample

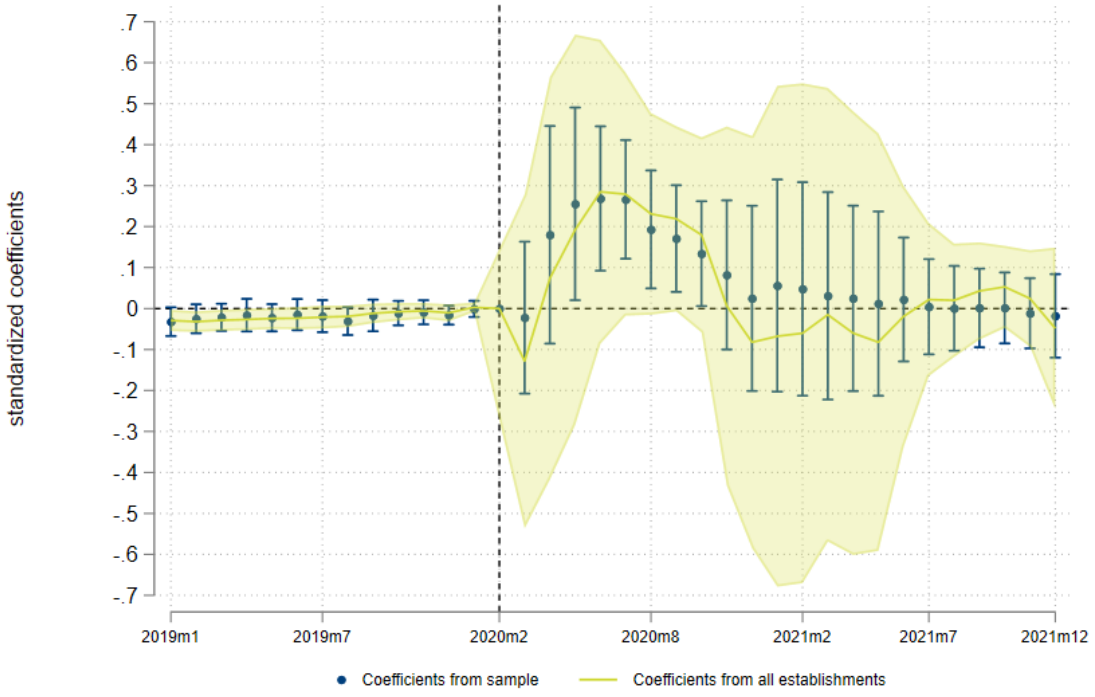
The dataset for the analysis consists of 6,736 establishments. To obtain representative results for all establishments in Germany, it is necessary that the industry distribution (treatment variation) in the sample and for all establishments in Germany is comparable. When aggregating all establishments to industries, the correlation of both industry distributions is $\rho = 0.829$ and is significant at the 0.1 percent level.

In addition, I use the entire establishment population in Germany that I can observe for the three-year period from 2019 until 2021 to estimate the model of Equation (5). In this dataset, I have 2,445,010 establishments for 36 months, which leads to 88,020,360 observations. Since I do not have survey information for almost all establishments I run an entropy balancing with a reduced set of control variables. I use the qualification structure, the shares of STEM workers, workers with university degree, employees in highly complex task and managers. Additionally, I use the wage percentiles, the work-from-home capacity, the loss of value added, and the distance to Bergamo of the establishment.

In Figure B.7, the blue markers and confidence intervals show the relationship between STW and GVC-related trade with China for the matched sample of 6,736 establishments and the full set of entropy balance controls. The green line shows the effects for the full population of establishments with the reduced entropy balancing.[25] It is clear that the regression results are not significantly different. The green area around the line shows the confidence interval. Only the confidence interval is significantly larger in the model with fewer control variables. A possible explanation for the smaller confidence intervals in the matched dataset could be that the additional control variables in the survey dataset explain important differences between establishments within sectors that influence the level of STW. In summary, the reduced dataset could be considered as representative for all establishments in Germany.

[25] For technical reasons, it is not possible to estimate the weights in the entropy balancing and the coefficients in the model with the full sample of 88,020,360 observations. For this reason, I divided the data set into 34 sub-samples. All samples have the same industry share distributions as the full dataset. The green line and area represent the mean coefficients of the 34 coefficients.

Figure B.7: Effects for the entire establishments population in Germany



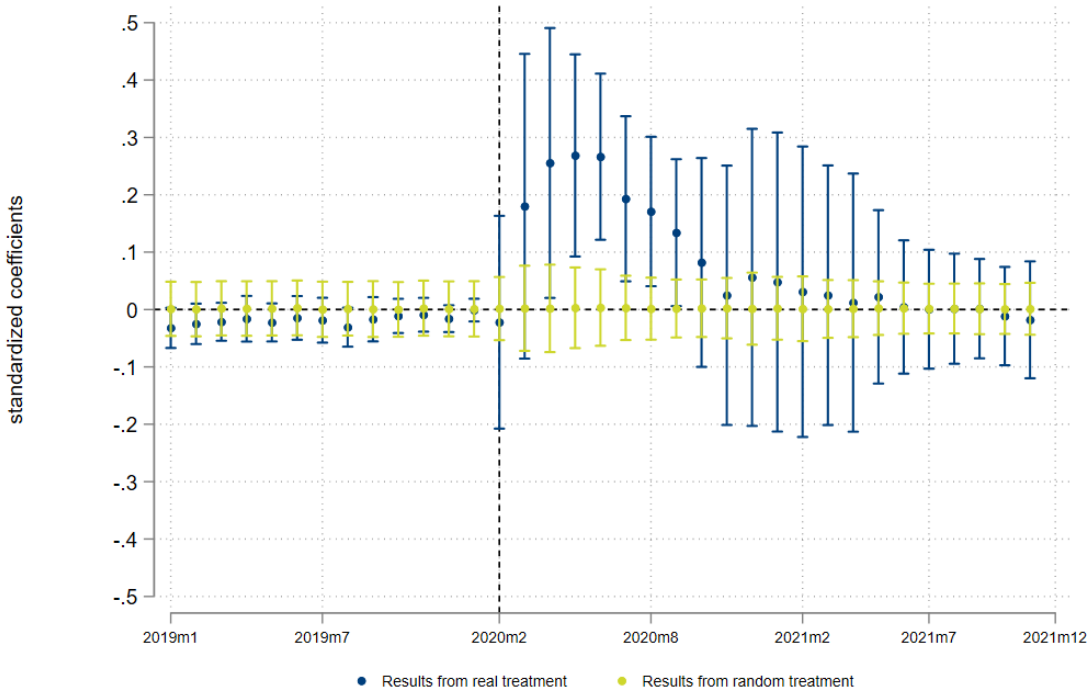
Note: All coefficients are in reference to February 2020. The blue coefficients indicates the relationship between STW and GVC-related trade with China for the main dataset. The green line and area indicate the effects and confidence intervals derived from the dataset for the entire establishment population and a reduced entropy balancing. The standard errors for the 95 percent confidence intervals are clustered on the industry level. Short-time work rates are calculated as the number of workers in short-time work in a given month over the employment level in June 2019.
Source: Federal Employment Agency, Statistics/Labour Market Reporting (2016), IAB Establishment History Panel, Alipour/Falck/Schüller (2023) and OECD (2022); own calculations. ©IAB

B.4 Random treatment specification

This robustness check tests the significance of the effects of GVC-related trade with China against a random treatment distribution. This approach can be interpreted as a more stringent test than testing the parameters against the null in the "normal" setting. To do so, I randomly draw the treatments 500 times from a normal distribution with mean and variance from the true GVC-related trade distribution:

$$GVC_{rand} \sim N(\mu_{GVC^{CHN}}, \sigma^2_{GVC^{CHN}}) \tag{7}$$

Figure B.8: Randomization inference for GVC-related trade integration with China



Note: : All coefficients are in reference to February 2020. GVC-related trade index is standardized ($\mu = 0, \sigma = 1$). The standard errors for the 95 percent confidence intervals are clustered on the industry level. EBCT weights are calculated for GVC-related trade with China. Top and bottom 1 percent firms are trimmed in the model. Short-time work rates are calculated as the number of workers in short-time work in a given month over the employment level in June 2019. The random coefficients (green) are the means of the treatment coefficients that are drawn from a normal distribution ($GVC_{rand} \sim N(\mu_{GVC^{CHN}}, \sigma^2_{GVC^{CHN}})$) with 500 repetitions.
Source: IAB Establishment Panel, IAB Establishment History Panel, Alipour/Falck/Schüller (2023)

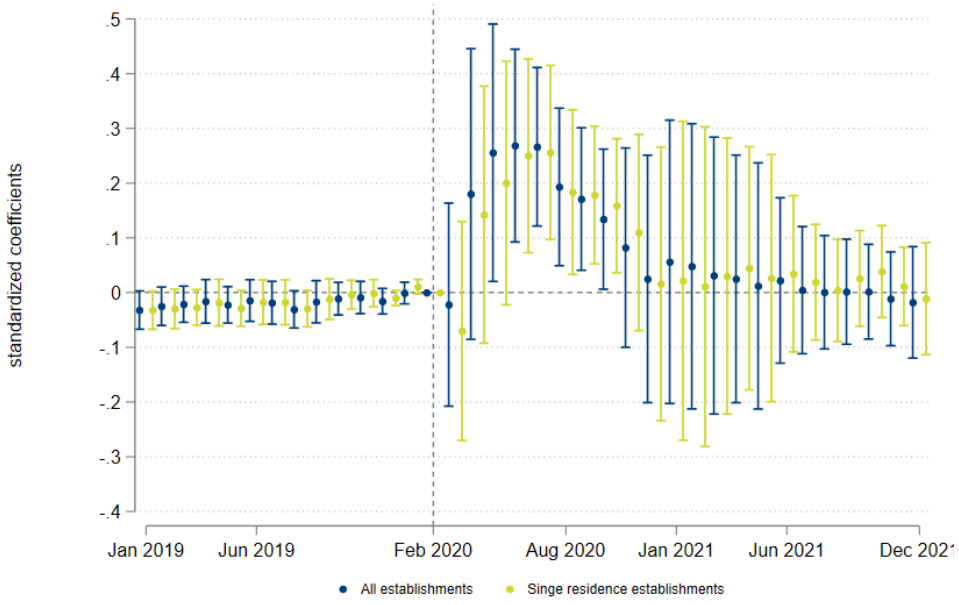
Figure B.8 shows the means of the coefficients of the 500 draws in green and the coefficients from the specification from Equation (5) in blue for GVC-related trade with China. The true coefficients differ significantly from the coefficients of the random treatment distribution in the first part of the pandemic. Furthermore, the random coefficients all intersect the zero

reference line and do not show any kind of pattern. This clearly indicates that the results not only significantly differ from zero but also from a randomly distributed potential treatment distribution.

B.5 STW reports on establishment level

As Kagerl/Schierholz/Fitzenberger (2022) show that firms with several establishments often report STW at a central office which leads to problems in reporting and data generation. For this reason, I will review the STW reports during the crisis in different datasets.[26] Moreover, multi-establishment firms tend to over-report STW because they may report STW for all their sub-firms. For this reason, in Figure B.9 I run the model on the subsample of firms with only one establishment. It is clear that including or excluding multi-establishment firms in the sample has almost identical effects.[27]

Figure B.9: Effects for single residence establishments



Note: All coefficients are in reference to February 2020. GVC-related trade index is standardized ($\mu = 0, \sigma = 1$). The standard errors for the 95 percent confidence intervals are clustered on the industry level. Short-time work rates are calculated as the number of workers in short-time work in a given month over the employment level in June 2019. The coefficients in blue indicates the effects from the main dataset. The coefficients in green indicate the effects when only single residents firms are included in the sample.
Source: Federal Employment Agency, Statistics/Labour Market Reporting (2016), IAB Establishment Panel, IAB Establishment History Panel, Alipour/Falck/Schüller (2023) and OECD (2022); own calculations. ©IAB

[26] See Section A.1 in the appendix for a detailed description. Further, the development of STW in the sample looks very similar to the development of STW of the entire population, see Figure A.1.
[27] Many thanks to Christian Kagerl for the explanation and the guidance on this topic.

B.6 Regression results for input supply problems

Table B.3: GCV-related trade and supply (table with controls)

	(1) OR/Std. error	(2) OR/Std. error	(3) OR/Std. error
GVC-related trade (China)	1.337***		1.593***
	(0.107)		(0.201)
GVC-related trade (world excluding China)		1.188**	0.820
		(0.087)	(0.106)
Number of employees	1.000	1.000	1.000
	(0.000)	(0.000)	(0.000)
ref: share low-skilled workers			
Share medium-skilled workers	0.976	0.994	0.970
	(0.046)	(0.051)	(0.043)
Share high-skilled workers	0.909*	0.910*	0.902**
	(0.047)	(0.047)	(0.047)
Share STEM occupations	1.100**	1.120**	1.109***
	(0.041)	(0.050)	(0.043)
Share professions with university degree	1.066	1.060	1.065
	(0.043)	(0.042)	(0.043)
Share employees in highly complex tasks	0.966	0.954	0.956
	(0.071)	(0.070)	(0.071)
Share managers	0.963	0.968	0.975
	(0.065)	(0.071)	(0.067)
Daily wage p(25)	0.776*	0.780*	0.785*
	(0.104)	(0.103)	(0.105)
Daily wage p(50)	1.238	1.177	1.239
	(0.295)	(0.284)	(0.299)
Daily wage p(75)	1.042	1.082	1.034
	(0.133)	(0.139)	(0.136)
Prop. intermed. consump. of turnover(in %)	1.110**	1.140***	1.098**
	(0.046)	(0.052)	(0.045)
Prop. business volume abroad (in %)	1.091**	1.141***	1.082**
	(0.044)	(0.049)	(0.042)
WfH Capacity	0.835	0.786**	0.855
	(0.095)	(0.093)	(0.091)
Loss of value added	1.055	1.097	1.045
	(0.113)	(0.120)	(0.107)
Distance to Bergamo (km)	1.040	1.036	1.041
	(0.040)	(0.040)	(0.040)
AKM firm-effects 2010-2017	1.163	1.156	1.190
	(0.262)	(0.261)	(0.270)
Constant	0.637***	0.649***	0.627***
	(0.056)	(0.058)	(0.051)
Observations	5298	5299	5298
Pseudo R^2	0.0415	0.0346	0.0432
Log likelihood	-3433.7	-3459.2	-3427.5

Note: The table shows the results of a logistic regression with odds ratios (OR). The outcome variable is question 1b option C of the IAB Establishment Panel 2020. It asks whether difficulties with the acquisition of inputs or with suppliers have negative impact on the establishment during the pandemic in 2020. Industry 5, "Mining support service activities" shows no gross exports with China, the number of observations reduces from 5299 to 5298 in Model (1) and (3). Significance levels: * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$ with clustered standard errors at the industry level.

Source: IAB Establishment Panel, IAB Establishment History Panel, Alipour/Falck/Schüller (2023) and OECD (2022); own calculations. ©IAB

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