COVID-19 and the GDP fall in Germany: A Business Cycle Accounting Approach

Scholl, Christoph

Nova School of Business and Economics

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Christoph Scholl

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Abstract

The Business Cycle Accounting method by Chari, Kehoe, and McGrattan (2007) helps identify theories that have quantitative promise in explaining economic fluctuations. In this paper, it will be applied to Germany to study the impact of the COVID-19 pandemic. The efficiency wedge primarily drove Germany's recession. The extensive lockdowns that prevented existing production factors such as labor and capital from producing at their full potential can explain the productivity loss. This suggests that the lockdowns are well identified as significant drivers of the reduction in economic activity and that their end would predict a sharp recovery in Germany.

Keywords

Macroeconomics, Business Cycles, Business Cycle Accounting, COVID-19, Germany, GDP Drop, Recession, Productivity,

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1. Introduction

On the 11th of March 2020, the World Health Organization categorized COVID-19 as a pandemic, which had already caused over 3 million infections and 207,973 deaths in 213 countries and territories at the announcement date (WHO 2020). The number one priority of the governments was to contain the virus and guarantee the functionality of the health care systems. In this process, governments imposed lockdowns. These enforced social distancing that impacted the world economy severely. Even though governments implemented policies, like short-time work subsidies and a stimulus package, to stabilize the economy and individual households, the OECD predicted the most severe output contraction ever recorded in Europe. Hence, the OECD forecasted a GDP drop in Europe of 7.9 percent for 2020 in their Economic Outlook report (OECD 2020). Only Ireland and China were able to grow in this environment.

The German GDP, for instance, dropped by 4.6 percent. Decomposing this recession will help to understand the crisis and be the contribution of this paper. For the manufacturing sector, COVID-19 and the accompanying social distancing policies negatively impacted the global supply chain throughout all their stages (Xu et al. 2020). Consequently, Germany's exports and imports slumped by 9.3% and 7.1%, respectively, during 2020, concluded the federal statistics office (Welle 2021). The lockdown led to the closing of many service providers like hairdressers and travel agencies. Moreover, many citizens increased their saving because of the overall uncertainty. Many companies' demand for goods and services declined, and as a consequence, turnover slumped. Only a few sectors like the tech industry profited from the new environment. While connecting the policies taken by the German government and the results of BCA, it will be concluded that the job retention programs and the stimulus package protected the economy from higher unemployment rates and numbers of insolvency which kept the economy in the pre-pandemic state. This allowed a jumpstart as soon as the circumstances made it possible to soften the social distancing measures. This jumpstart started in June 2020 when

more than 50 percent of the employees who had received short-time subsidies started to work full-time again. The process of labor allocation was skippable since the workers were still employed, and transition to full-time work could go smoothly without efficiency losses. This indicates that the German government's job retention programs and the stimulus package were successful. The data used for this analysis shows that the recovery was quick, and the output per capita increased by more than eight percent in quarter three of 2020.

After a quick and decisive implementation of restrictive policies of unprecedented magnitude in March 2020, it is vital to understand the extent to which these actions impacted the German economy. The Business Cycle Accounting (BCA) method is a diagnostic tool that sheds light on the mechanisms through which shocks and policies affect the joint dynamics of macroeconomic variables. The method is based on two components. The equivalence result clusters a large class of models with different types of frictions that are equivalent to a prototype model with different types of time-varying wedges, which distort agents' equilibrium decisions in otherwise competitive markets. The accounting result shows that the wedges can be measured through the lens of the prototype economy such that together, the four wedges account for all the variation in the data. If the prototype economy gets simulated, the four measured wedges can replicate all the movements in observables. Identifying the most relevant wedges for the period under analysis sheds light upon the relevant theories that can be used or need to be formulated, in order to understand the mechanisms through which the observed economic fluctuations came to be.

For Germany, it is evident that the efficiency wedge explains 72% of the variance in output[1], 75% in hours worked, and 31% in investment. When focusing on output and hours worked, the efficiency wedge is the dominant margin through which the pandemic shock and policies

[1] This relates to the computation of the ϕ statistic. See section Definition ϕ statistic for details.

implemented impacted the economy. This can be rationalized by the extensive lockdowns which that prevented existing production factors such as labor and capital, from producing at their full potential and thus reflect productivity losses. This suggests that indeed, to the extent to which there was no significant job destruction, the lockdowns are well identified as major drivers of the fall in economic activity. As observed, their end would predict a sharp recovery in output and hours worked. The picture is more nuanced for investment, as the labor wedge alone explains about half of the variation and the efficiency wedge about 31%.

The relevance of Germany for European economic dynamics cannot be understanded as it is the largest economy of the European Union and has a considerable degree of synchronization with business cycles in the area (see Aguiar-Conraria et al. (2017)).

This paper is structured as follows. First, related literature will be summarized. Afterwards, the policies and measure implemented by the German government will be listed.

Thirdly, the BCA methodology and the data used will be explained. Next, the result of BCA will be presented and explained, and the policies and measures of the government embedded in the findings of the BCA. In the end, an overview of the results will be presented.

2. Literature review

The discussion about the COVID-19 economic crisis in Germany and worldwide is controversial. The goal of this paper is to contribute to this discussion based on the findings of the BCA. One reason for the controversy is that all political measures must primarily ensure the functionality of the medical care and health system, while economic and social goals were neglected. A conflict between the purpose of containing the virus and economic prosperity is visible, and containment always got prioritized. Nevertheless, economists argue that a looser containment policy would lead to more drastic quarantine measures and thus higher economic costs in the future (Bofinger et al. 2020).

The discussion gets slightly less controversial when excluding the conflict of virus containment and economic policies.

The OECD has provided model-based estimates by Boone (2020) showing that the demand of China and other importing economies for German intermediate goods, capital goods, consumer goods and services is also affected by the coronavirus. Consequently, they will reduce their demand (Boone 2020). Moreover, it is unlikely that a catch-up effect will fully offset this decline in demand after the end of the crisis. If supply chains are interrupted, purchases and sales can be made up later. However, according to an analysis of ship data from the Red Sea, Europe's trade in goods with Asia is, after the first COVID-19 wave, about 20 percent below normal levels (Felbermayr, Hinz, and Mahlkow 2020). Moreover, social consumption (i.e., restaurant visits or private vacations) that were canceled or not consumed will not necessarily be made up for later (Bofinger et al. 2020).

The same authors found another factor that might intensify the COVID-19 crisis. Reactions in the financial sector may trigger a fall in demand. Banks may have to restrict the supply of credit if they find shortages in outstanding loans to companies that have been hit hard by the crisis. In addition, many companies will fully utilize their credit lines to build up cash reserves for the crisis. This credit expansion may crowd out bank financing of private investment and other loans (Bofinger et al. 2020).

Nevertheless, COVID-19 is a recent macroeconomic shock and cannot be categorized, yet. Baqaee and Farho (2020) used a disaggregated model with multiple sectors, multiple factors, input-output linkages, downward nominal wage rigidities, credit constraints, and a zero lower bound for their analysis. They concluded that the COVID-19 crisis is a messy combination of disaggregated sectoral supply and demand shocks. On the one hand, some sectors struggled with supply constraints and sought to keep up with demand. On the other hand, other sectors are underutilized and would lay off workers to reduce excess capacity due to lack of demand

(Baqaee and Farhi 2020). Furthermore, the authors point out that supply and demand shocks complicate the implementation of appropriate policy measures. Demand-enhancing measures such as increased government spending could exacerbate supply shortages and inflation. While, supply-enhancing measures such as easing closures could prove ineffective in reigniting economic activity when applied to sectors with demand constraints (Baqaee and Farhi 2020).

Like Balta, Fernandez, and Ruscher (2013), other authors also focused their research on the recovery of a crisis like the one after the financial crisis of 2008. They claim that the slow recovery was partly due to the high level of uncertainty. The authors used a business and consumer survey to assess uncertainty and their econometric analysis indicates that uncertainty hinders economic growths and decreases consumption and investment (Balta, Fernandez, and Ruscher 2013). Their results are in line with Bernanke's economic theory, which found that high levels of uncertainty can affect economic activity through various channels such as investment, consumption, and employment. When investment, consumption, or employment decisions are costly to revise, high uncertainty incentivizes actors to postpone or even cancel their decisions. Actors then wait until the uncertainty is removed and more information is available, slowing down economic activity (Bernanke 1983).

3. Pandemic Policy Environment in Germany

Angela Merkel, the German chancellor, said "the most efficient measure to mitigate the spread of this infection is to increase social distancing" on the 16th of March 2020 (Merkel 2020).

Lockdown

Many Governments worldwide have chosen to increase social distancing by imposing a lockdown. In Germany, this lockdown started on the 22nd of March and ended seven weeks later on the 7th of May. During that time, restaurants and cinemas were closed, as were schools and day-care centers. Holiday trips were canceled. Visits to elderly people's and nursing homes

were forbidden. Seriously ill and dying people were no longer cared for by their relatives. Many workers were asked to work remotely, and only essential shops like supermarkets, drugs stores, banks, and petrol stations remained open (Bosen and Thurau 2021).

Stimulus Package

The lockdown caused by the necessity to increase social distancing led to a freeze of the economy, and uncertainty rose for investors, employees, and employers. To limit the increase of uncertainty, the government agreed on a stimulus package unprecedented in Germany's history. This stimulus package included 57 individual measures to allocate 130 billion euros to stabilize the economy and individual German households, and to promote investment in future technologies for climate protection (Dorn, Fuest, and Neumeier 2020). Simulations from July 2020 concluded that the package would increase German GDP by 0.9 percentage points in 2020 (Wollmershäuser et al. 2020). During the financial crisis in 2008 and 2009, primarily banks needed to be stabilized. This time, most companies, from manufacturers to service providers, were addressed by this government measure. It was necessary since the financial sector needed to cut credit supply, as Bofinger et al. (2020) claimed. Uncertainty did not increase homogenously. Sectors that experienced higher uncertainty had higher difficulties getting a loan than sectors less impacted by the virus. Furthermore, this time, it was not a market failure like a bubble burst that initiated the contraction. Lufthansa's pre-pandemic lucrative business model became unprofitable at the time of national and international travel restrictions for business and vacation trips. Suddenly, a well-run industrial Champion turned into a company that needed just below nine billion euros from the government to survive (Dorn, Fuest, and Neumeier 2020). Camous and Claeys (2020) call this possibility to protect industry champions the policy space or more accurate fiscal power (Camous and Claeys 2020). To demonstrate the fiscal power of the German state, Vice-Chancellor Olaf Scholz and the minister for economic affairs Peter Altmaier announced unlimited liquidity support when it came to guarantees and

liquidity coverage on the 13th of March 2020. The government has promised that a lack of money and political willingness will not be the reason for a company's failure (Scholz and Altmaier 2020). This government measure directly counteracts the fear of Bofinger et al. when they assumed that companies would fully use their credit lines to build up cash reserves for the crisis.

Short-Time Work

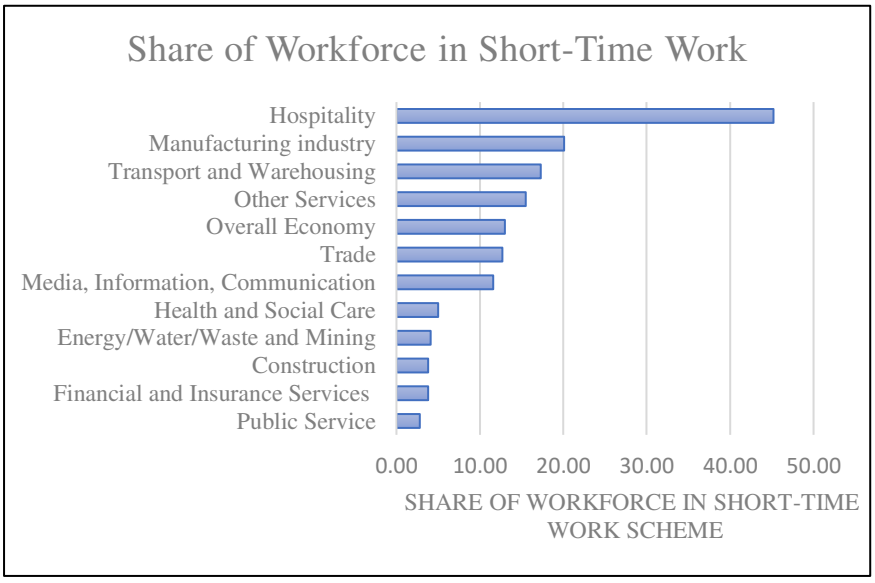

Figure 1: Share of Workforce in Short-Time Work per sector

Also linked to social distancing and the fiscal power of the German government are the job retention schemes like short-time work. Short-time work supports companies when there is a severe loss of work due to an unavoidable event, like COVID-19. In this extreme economic situation, employees work less than their employment contracts say for a period of time but still receive a large portion of their wages: employees continue to receive pay based on their new, actual working hours. The resulting pay gap is made up by the short-time allowance provided by the Federal Employment Agency. Short-time work can affect the entire workforce or only some employees (Personio 2020).

As mentioned prior, the COVID-19 outbreak is not a market failure. For this reason, it was the government's strategy to integrate 13 percent of the total workforce in the short-time work scheme to prevent the companies from reducing the workforce and losing internal knowledge, in order to initiate a jumpstart of the economy after the circumstances return to normal. Thus,

the massive use of short-time work has prevented a dramatic increase in the unemployment figures in the wake of the Corona pandemic (Pusch and Seifert 2020). The success is shown in a comparison between the unemployment rate of Germany and the USA since short-time work was not used by the latter. According to OECD Economic Outlook No. 109 data, the unemployment rate increased from 3.58 percent in the first quarter to 4.17 percent in the second quarter in Germany. However, in the USA, the unemployment rate rose from 3.80 percent to 13.02 percent over the same period. For a detailed view of the labor market dynamics and impact of COVID-19 in the U.S. labor market, see Brinca et al. (2021). Another effect of the job retention scheme is the increased compensation per hour worked marginally while compensation per employee decreased significantly (Anderton et al. 2021). Furthermore, the IMF calculated that unemployment would have averaged almost three percentage points higher across the German states in the second quarter of 2020 (Caceres, Dao, and Mineshima 2021).

As shown in Figure 1, the highest shares of the workforce included in the short-time work scheme were employees in the hospitality sector (45.2 percent), manufacturing sector (20.1 percent), transport and warehousing sector (17.3 percent), and the “other services” sector (15.5 percent). The shares of the short-time work in those sectors also demonstrate which economic sectors in Germany were the most affected. While hospitality and other services entered the job retention scheme due to the closing of shops for social distancing reasons, the manufacturing, transportation, and warehousing sectors entered short-time work due to the distortion of global supply chains. To emphazis the importance of the German manufacturing sector, the country has the second-highest trade surplus, it is the biggest economy in the European Union, and has the third-highest manufacturing sector share of total GDP. However, according to World Bank Data, imports decreased by more than 8% in 2020 compared to 2019. In 2019, China is the world’s largest exporter and Germany’s largest importer. Since China was the first country to impose a strict lockdown and thereby stopped producing essential intermediate supply goods

for Germany, the manufacturing sector hit a supply shortage, and production lines needed to be shut down (Van Der Putten 2020).

This supply shortage had an even more dramatic impact on industries that adapted just-in-time production. Those companies, like automotive giants Mercedes, BMW, and Volkswagen, carry low inventories and suddenly faced a devastating supply shortage. Moreover, there are often no alternative suppliers who can deliver instantly and at acceptable prices to keep the production line running (Van Der Putten 2020).

Since some production sites were closed, goods could not be produced, and exports decreased by 9.3 percent. Another reason for the export slump was decreasing demand. The United States of America, Germany's biggest receiver of exports, imported €95.9 billion, a 12.5% decrease compared to 2019 (Welle 2021).

Suspension of Insolvency

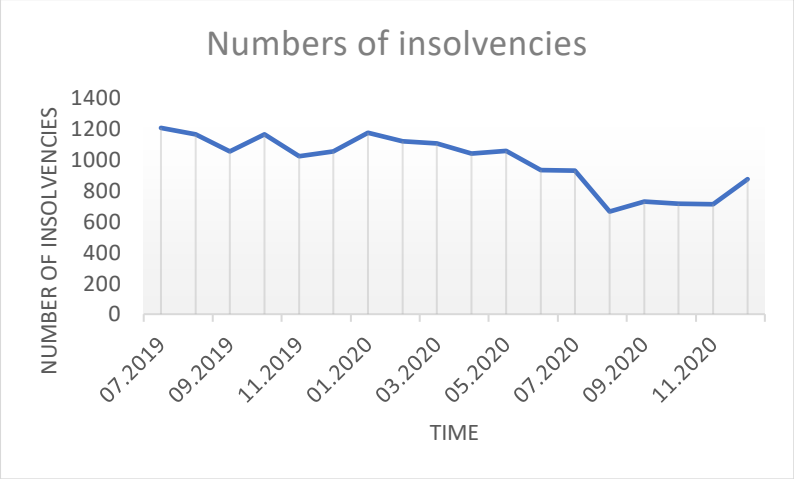

Figure 2: Number of Insolvencies

Another measure implemented by the German government is the suspension of insolvency. Insolvency is the inability of a debtor to pay his/her debts or liabilities to creditors (Federal Statistic Office 2021). For many companies, turnover has collapsed but the costs for employees and buildings continue to accure. The companies are threatened with insolvency, and the Corona aid from the federal government and the federal states does not always flow promptly. Therefore, companies wondered whether they had to file for insolvency (Schultze and Braun 2021). This suspension aims at avoiding those insolvencies. Figure 2 shows the absolute number of insolvencies registered by the

Federal Statistics Office. It can be seen that the numbers did not increase but even slightly decreased during the recession.

Value-Added Tax Reduction

The last mentioned policy which was implemented in July 2020, was the reduction of the value-added tax. The standard value-added tax rate was reduced from 19 percent to 16 percent to enhance consumption (Dorn, Fuest, and Neumeier 2020). According to the model estimation of Clemens et al., the reduction increased private consumption by about one percent and gross domestic product by 0.5 percent (Clemens et al. 2021). Since international demand also plummeted and exports shrank by 9.3 percent in 2020, this value-added tax reduction was helpful to enhance domestic demand since the German government could not influence international demand.

4. Methodology and Data

General data collection

The data used for this analysis was taken from different databases of the OECD. In May 2021, the OECD published the Economic Outlook: Statistics and Projections No 109. From this dataset, the quarterly data of the variables Government consumption, private consumption, gross domestic product, gross fixed capital formation, and the im- and export of goods and services of Germany was taken. All variables are nominal values. For this reason, the deflator of each variable was taken to calculate a new base year 2018.

Moreover, total employment, hours worked per week, and the short-term interest rate were taken from this dataset. The information on total population can also be found in this dataset but only on an annual basis. The last variable downloaded, which is only available on an annual basis, is the share of the working-age population (age 15 to 64). This information comes from the OECD Demography database. Total population and the percentage of those of working-age

were used to calculate the working-age population. The total and working-age population data with the annual frequency were interpolated linearly to adjust the data to a quarterly frequency.

The BCA method uses the maximum likelihood estimation. Therefore, increasing numbers of observations enhance the precision of the results. For Germany, the OECD data of the population starts after reunification in 1990. The final dataset interpolated data was used for the analysis in MATLAB.

Business Cycle Accounting

The BCA will be applied to contribute to the discussion of the type of crisis COVID-19 inflicted on the German economy. Chari, Kehoe, and McGrattan (2007) proposed the BCA method to guide researchers that develop quantitative models of economic fluctuations in order to allow the models to produce business cycle fluctuations comparable to those in the data.

The method has two components: an equivalence result and an accounting procedure. The equivalence result combines a large class of models with different mechanisms that are mapped back to a prototype economy with four time-varying wedges. Those wedges are like total factor productivity (the efficiency wedge), a labor income tax (the labor wedge), an investment tax (investment wedge), and government expenditures plus net exports, (the government wedge) that distort equilibrium conditions. As to the accounting result: the accounting procedure also has two components. It begins by measuring the wedges, using the equilibrium conditions of a prototype model together with data. The measured wedge values are then integrated back into the prototype model, one at a time and in combinations, to evaluate how much of the observed movements of output, labor, and investment can be assigned to each wedge, separately and in combinations. In total, the four wedges account for all movements that were observed. However, the most relevant and informative exercise is how much we can explain movements in the data by looking at a subset of alleged wedges. Identifying the most relevant wedges for the period

under analysis sheds light upon the relevant theories that need to be formulated to understand the mechanisms through which the observed economic fluctuations came to be.

BCA was applied in the BRIC countries in 2013 by Cho and Doblas-Madrid and in the United Kingdom in 2008 by Kersting. Brinca & Costa-Filho (2021a,2021b) look specifically at output falls and depression episodes and the international transmission of crisis, in the context of Brasil and Mexico respectively. Brinca et al. (2021) performs an extensive literature review regarding previous BCA exercises and methodological departures from the prototype economy in Chari et al. (2007). Sustek (2010) for example introduces an extra asset in the form of government bonds and a Taylor rule, adding two new first order conditions ot the prototype economy and two additional wedges – the taylor rule and asset market wedges. This extra structure allows the author to make claims regarding the relevance of different wedges to the nominal side of the economy. Brinca (2013) applies the methodology to the Swedish economy in both the 1990 and 2008 crisis.

Prototype Economy

This section is based on Chari et al. (2007) and closely follows Brinca (2014). The prototype economy is a growth model which includes savings and labor decisions and is neoclassic. Moreover, it has four exogenous random variables called efficiency wedge A_t, investment wedge $1/(1+\tau_{xt})$, labor wedge $1-\tau_{lt}$ and the government wedge g_t. In this economy, the equilibrium is therefore defined by the aggregate resource constraint

(1) $c_t + x_t + g_t = y_t$

where y_t is output per capita, c_t consumption per capita, x_t investment per capita, the production function

(2) $y_t = A_t F(k_t, (1+\gamma)^t\, l_t)$

the labor-leisure choice

(3) $-\frac{U_{lt}}{u_{ct}} = (1-\tau_{lt})A_t(1+\gamma)F_{lt}$

and the savings optimality condition

(4) $u_{ct}(1+\tau_{xt}) = \beta E_t[u_{c,t+1}\left(A_{t+1}F_{k,t+1} + (1-\delta)(1+\tau_{x,t+1})\right)]$

where a function's subscript represents the function's derivative for the subscript argument, evaluated at t. It is also assumed that g_t fluctuates around the trend $(1+\gamma_z)^t$ (Brinca 2014).

Functional forms and calibration

The utility function is additively separable in logarithmic consumption and leisure, i.e., $u(c,l) = \log(c) + \psi\log(1-l)$. In capital and labor, the production function is linear homogenous, i.e., $F(k,l) = k^{\theta}l^{1-\theta}$. Except for the population growth rate, which is country-specific, the values used for the parametrization of the model are taken from Chari et al. (2007). From Kehoe and Prescott (2007), the growth rate of labor augmenting technical changes is taken. For the steady-state quantities, the model is solved, and the equilibrium is derived from the values found in Table 1.

Table 1: Calibration

y_z	β	δ	ψ	ϑ
0.02	0.97	0.05	2.24	0.35

By log-linearization around the steady-state, the equilibrium decisions rules are derived, assuming that the exogenous states (the wedges) track a four-dimensional vector auto-regressive process of order one where the variance-covariance matrix Q = $B'B$ and the error term is expected to be multivariate normal with mean zero as depicted below:

$$\in \sim MVN(0, B'B), \qquad \omega_{t+1} = P_0 + P\omega_t + \epsilon_{t+1}$$

The Kalman filter is used to back out the wedges and the data as observables. The procedure is (i) solving the model for steady-state quantities; (ii) compute decision rules by log-linearization around the steady-state; and (iii) build for the model a state-space representation, with a law of motion matrix for the state variables. Some important identification issues have

been brought forth by Brinca et al. (2022), since the procedure implies estimating thirty parameters which given the usual time length of macroeconomic series can be problematic. However, a more through analysis if these issues is outside the present scope of this paper. Those are subject to a matrix with the optimal choices for output, hours, investment, and government consumption as a function of the state and gaussian innovations.

As in Chari et al. (2007), the measurement errors are set equal to zero. The likelihood that the wedges are jointly normal is calculated, and the optimization program affects the selection of the parameters of the VAR, i.e., the vector P_0 and the matrices P and B so that the likelihood is maximized.

Definition ϕ Statistic

The definition can be found in Brinca et al. (2016). The ϕ statistic captures how closely a specific component, like the output component due to the efficiency wedge, follows the actual development of the variable, say, output. The authors set for the decomposition of output

(5) $\phi_i^Y = \frac{1/\sum_t (y_t - y_{it})^2}{\sum_j \sum_t (1/(y_t - y_{jt})^2)}$,

where y_{it} represents the output component due to wedge I = (A, τ_l, τ_x, g). For labor and investment, comparable statistics were computed, and the desirable feature those statistics are that the ϕ statistic ranges from [0, 1], and sum to one when added. Moreover, when a specific output component follows output perfectly, the wedge reaches the maximum value of 1. For this to happen, $(y_t - y_{it}) = 0$ needs to hold for all t (Taylor and Uhlig 2016).

5. Application Business Cycle Accounting

This section will first look at the macroeconomic variables needed for the BCA, prototype economies, and the method's results.

Data Observation

In MATLAB, the collected data was transformed to calculate five macroeconomic variables quarterly as needed for BCA application. Those five variables are output per capita, investment per capita, hours worked as a fraction of a day per capita, government spending per capita, and the working-age population. The research at hand uses the log-linear detrending method on the output per capita, the hours worked per capita, the investment per capita, and government spending per capita. Quarter three of 2019 until quarter four of 2020 but especially at the evolution of the variables in quarter two and three of 2020 are at the focus of this work.

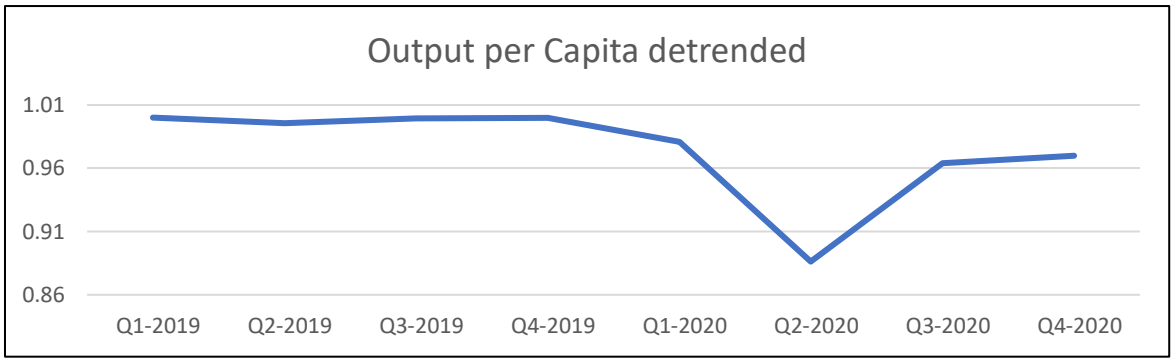

Figure 3: Output per Capita detrended

Figure 1 illustrates the development of output per capita. The impact of COVID-19 is visible. Starting in quarter one of 2020, output per capita starts to drop, but in quarter two of 2020, output plummets by more than ten percent. Output recovers in quarter three but does not reach the pre-pandemic level and continues to recover slowly in quarter four of 2020. The sharp decrease can be explained by the lockdown and the implementation of short-time work. Employees remained employed, but the distortion of the global supply chain and the closing of shops limited the output those sectors could potentially produce, leading to productivity losses.

When looking at the hours worked as a fraction of the day per capita, the picture is very similar to the output per capita development until quarter three of 2020. In the pre-pandemic period, the fraction does not fluctuate much but starting in quarter one and especially two of 2020, the hours worked drop by almost nine percent.

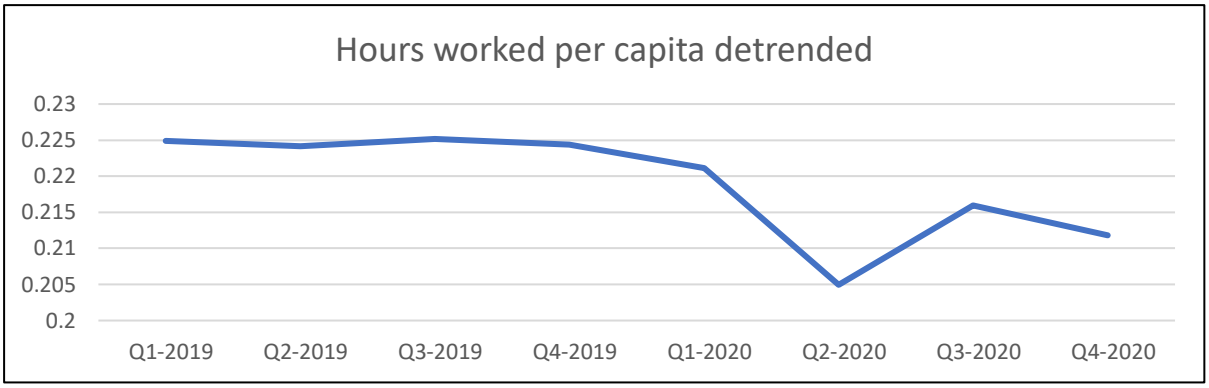

Figure 4: Hours worked as a Fraction of a Day per Capita detrended

Despite a strong recovery seen for the output per capita, the hours worked per capita recover less extensively and not before quarter three of 2020. In quarter four of 2020, hours worked drop again. Again in the case of hours worked, the lockdown and resulting short-time work scheme are the reasons since short-time work reduces the hours worked as defined in the employee's employment contract. Furthermore, unemployment in Germany consistently increased from 3.58 percent in the first quarter to 4.55 percent in the fourth quarter, also decreasing hours worked.

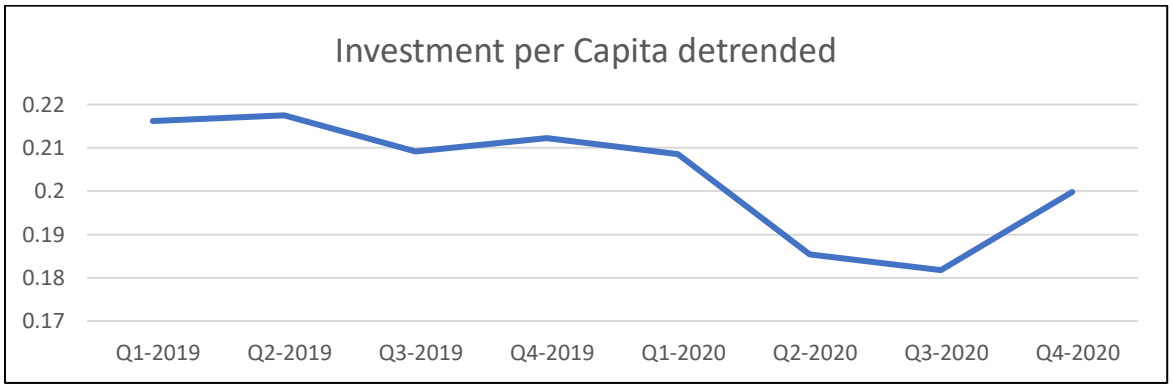

Figure 5: Investment per Capita detrended

Investment per capita differs from output and hours worked per capita. The fluctuation in pre-pandemic times is more extensive, and from quarter one to quarter three of 2020, investment drops by more than 14 percent. Moreover, the recovery lags one quarter behind output and hours. However, we can see it recovering just as substantially in quarter four of 2020 compared to the increase in output per capita in quarter three.

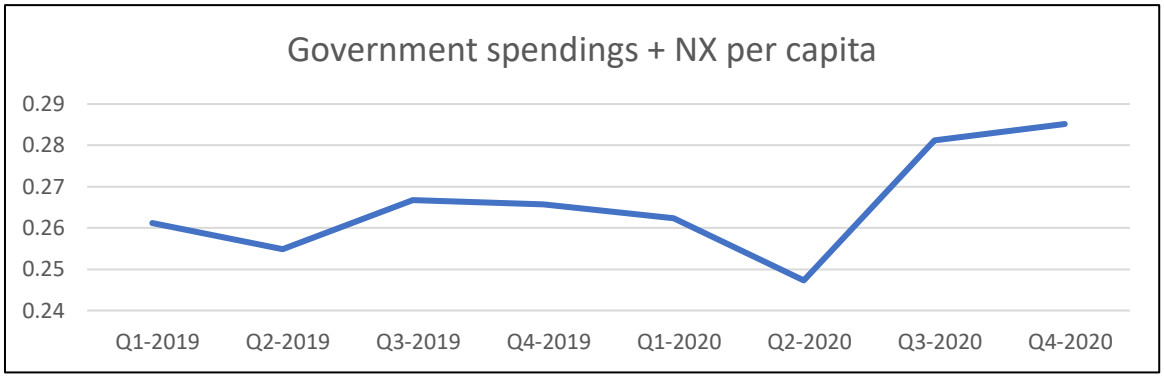

Figure 6: Government spending's + Net Exports per Capita detrended

Government spending plus net exports dropped in the second quarter of 2020. However, after the announcement of the Vice-chancellor and minister of economic affairs in March 2020, the government's spending plus net exports increased sharply due to the unprecedented stimulus package. To further emphasize this acceleration in government spending, it is need to mention that exports decreased at the same time. Still, government spending plus net exports increased by 15 percent in the second half of the year.

Next, emphasis is on the simulations of the prototype economies for each wedge for output, hours, and investment and compare those to the actual values of the variables.

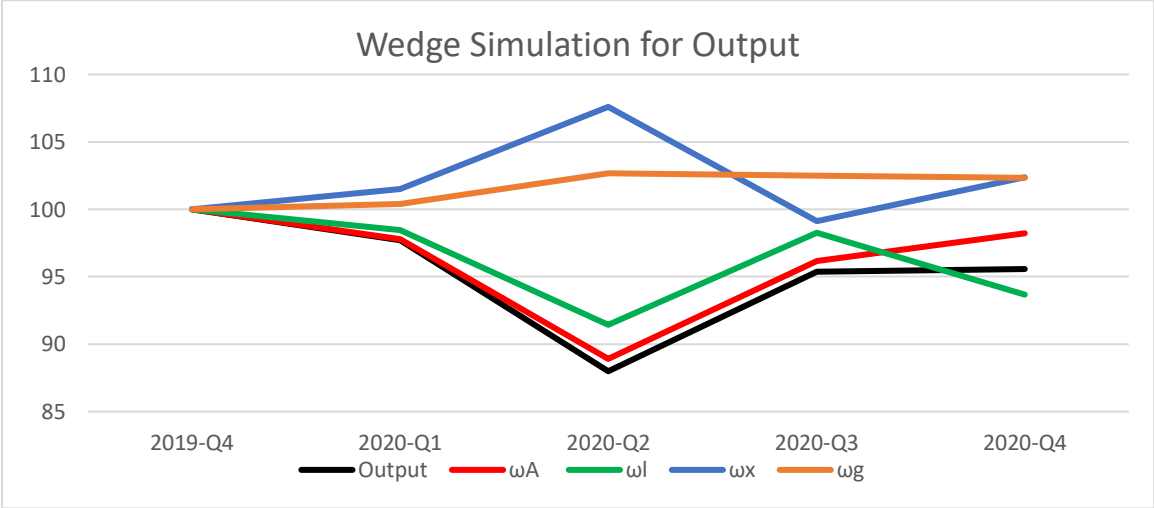

Figure 7: Wedge Simulation for Output

Figure 7 shows the output developments of each wedge if all shocks could be explained by one wedge alone. In this case, $(y_t - y_{it})$ would be equal at each t. Here, ω_A follows the actual output to the closest. Consequently, the efficiency wedge can explain most shocks. The labor

wedge ω_l follows a similar trend but less closely. In quarter four, the efficiency wedge keeps increasing while the labor wedge decreases, and the actual output stagnates. Therefore, the labor wedge assumingly gained importance at the end of the year. The investment and government spending wedge differentiate entirely from the actual output and only explain output marginally.

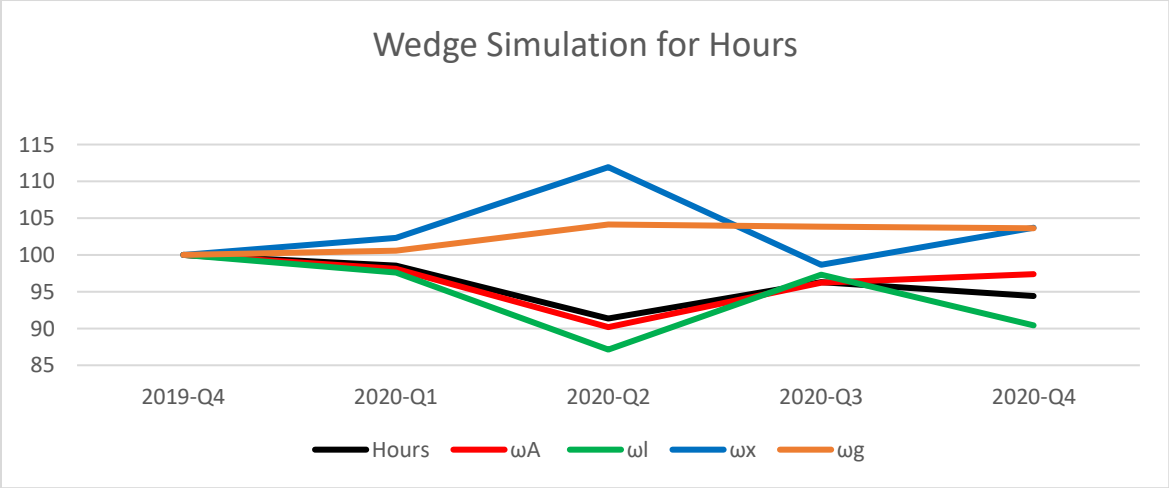

Figure 8: Wedge Simulation for Hours

Figure 8 shows the development of hours worked and how hours worked would fluctuate in a prototype economy where all shocks are explained by one of the four wedges. The representation does not change much compared to output. Again, the efficiency wedge follows the actual hours worked the closest. This time the labor wedge also follows the trend but less closely. However, we can see once more how hours separate from the efficiency wedge prototype economy in quarter four and follows a path between the efficiency and labor wedge.

For the development of the actual investment, the picture differs entirely. This time not a single wedge follows the trend of actual investment. In Figures 7 and 8, it is evident that the efficiency wedge explains most of the shocks.

When looking at investment, the ϕ statistic is needed to determine which wedge explains the most shocks on investment. From quarter four of 2019 to quarter three of 2020, we can see that the labor wedge is closest to and fluctuates around actual investment but therefore does not follow its trend.

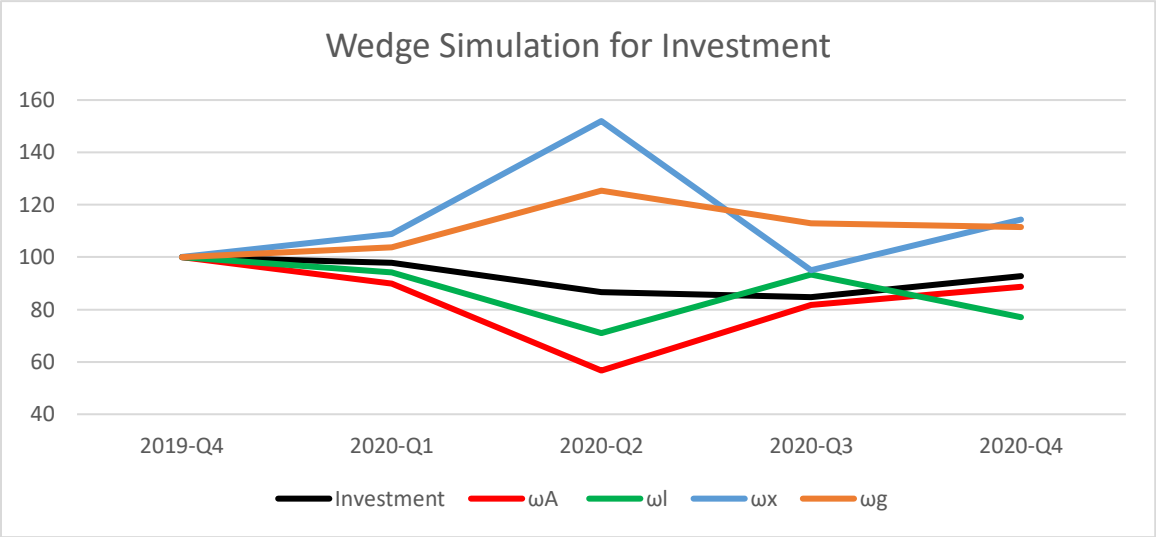

Figure 9: Wedge Simulation for Investment

In quarter four of 2021, the efficiency and actual investment started to follow the same trend very closely. In the previous quarters, the efficiency wedge overestimates the investment decrease while the investment and government wedge overestimate the increase in investment.

Table 2: φ statistics

	ω_A	ω_l	ω_x	ω_g
Output	0.7216	0.2465	0.0131	0.0188
Hours	0.7469	0.214	0.0144	0.0247
Investment	0.3069	0.5181	0.0614	0.1135

The ϕ statistics, which measures how much each wedge can explain the variance in output, hours, and investment. The θ-statistic shows that the efficiency wedge can explain more than 72% of the output variance, 75% in hours worked, and 31% in investment. Therefore, the efficiency wedge is the dominant margin through which the pandemic shocks negatively impacted the economy by hindering productivity. As seen in Figure 9, the picture is a bit more nuanced for investment, as the labor wedge alone explains about half of the variation and the efficiency wedge about 31%.

To conclude, the application of the BCA methods estimates that the COVID-19 recession in Germany should be primarily thought of as an efficiency wedge recession, with some role for the labor wedge. This means that for productivity, the first-order effect is that production factors are prevented from being efficiently used, tampering productivity.

The next chapter combines the BCA results and the COVID-19 policy environment in Germany to understand what drives productivity down.

Impact of policies of the German government on productivity

As mentioned in Chapter 4, the German government has implemented many policies primarily to guarantee the functionality of the health systems. At the outbreak's start, the government needed to act quickly and decisively. Now, it is essential to interpret the introduced policies' impacts to define a strategy for a quick recovery and to identify lessons learned.

The implementation of the lockdown had a severe impact on the economy, especially on its productivity. Since the COVID-19 pandemic is not a market failure, the government's strategy was to keep the economy in the pre-pandemic state, introducing policies to reach that goal even though this approach faced many challenges. The first challenge is that China imposed a strict lockdown in its country on the 23rd of January 2020. Germany's manufacturing sector is highly dependent on China's input and intermediate goods supply. Since parts were missing, the production line needed to stop, and the factories were overstaffed. Under normal circumstances, the manufacturer would reduce the workforce to prevent overstaffing and increase efficiency per worker. Short-time stopped the reduction and replaced the burden of the employees' wages partly by the government subsidies. The social distancing measures hit the hospitality and other service sectors more seriously—companies in those sectors had to shut down completely for the duration of the lockdown. Due to short-time work, companies could maintain their staffing levels even though they did not have any revenue then. In the case of manufacturers experiencing supply shortages and of service providers forced to close, short-time work harmed

the productivity factor since output per worker dramatically decreased. Moreover, it prevents human capital from moving to more productive activity and reduces the labor factor.

However, the advantage and productivity-enhancing aspect of short-time work is that labor does not need to be newly allocated to companies when the lockdown measures are lifted. Companies can operate on full potential from day one onward.

Still, those companies needed to pay rent and had outstanding liabilities, and therefore the stimulus package was introduced. The goal of those cash transfers and guarantees was to reduce investors' uncertainty, stabilize individual households and the economy, and keep companies liquid. However, as Figure 5 shows, investment has significantly decreased. The reason for this change was the increasing uncertainty, and this changed behavior decreased the capital factor. The stimulus package was necessary for the companies and kept them running. Nevertheless, the government was not prepared to send those cash transfers to all companies instantly. This was the reason why the government suspended insolvency. Usually, insolvencies indicate the state of an economy, but in the COVID-19 recession, the number of insolvencies has decreased. This suspension of insolvencies also harmed the productivity factor. Often issues related to the financial system's performance are associated with distortions in the Euler equation or the investment wedge. Indeed, the financial system is what allows agents to transfer resources across time and states of the world. However, the financial system also has the crucial function of channeling resources to their most efficient uses, which is not captured by the investment wedge but rather the efficiency wedge. Since the government could not immediately identify the profitable companies, zombie companies, companies that would go bankrupt soon even without the COVID-19 pandemic, received cash transfers. Therefore, the money invested in an unprofitable company was not allocated efficiently to a profitable company. Consequently, the employees of those unprofitable companies remain working for an unproductive company

instead of changing to jobs where they could be more productive. Hence, this measure decreased the capital and labor factor.

So far, many measures have decreased productivity. Under ordinary circumstances, companies invest in technology that enhances productivity. However, Bernanke argued in 1982 that in times of persistent high uncertainty, companies prefer to wait until the uncertainty is resolved to decide on matters that are expensive to revert. For this reason, companies are assumingly more risk-averse decision-makers even when they could invest in new technology to improve productivity.

In July, the value-added tax reduction was introduced. The economy was recovering, and the social distancing measures were relaxed. Therefore, the timing of this measure was well chosen since the supply shortage could often be resolved, the demand was herewith stimulated, and the catch-up effect for goods was initiated. In 2016, Brinca et al. applied the BCA method to OECD countries to analyze the financial crisis 2008 and 2009. They found that the efficiency wedge equally was the main driver for Germany at that time (Brinca et al. 2016). It can be assumed that Germany learned from this recession. Moreover, more than 50 percent of the short-time workers left this job retention scheme. Therefore, the incomes of many German households increased. The success can be seen in Figure 7. The output per capita increased by more than 30 percent in Q3 of 2020 but is still more inefficient than before the crisis. Another effect of value-added tax reduction is that the workers might reexamine their labor-leisure decision since the price decrease might influence them to value leisure more and labor less since satisfying their needs became cheaper. Depending on the sector and company where the worker is occupied, productivity might in- or decrease.

6. Conclusion and outlook

The COVID-19 virus was first detected at the end of 2019, leading to a health crisis in 2020. Suddenly, the functionality of the health care system was prioritized while economic and social

goals got neglected. Following the declaration of a pandemic in March of 2020, the world economy fell into a deep recession. In many developed countries, governments imposed lockdowns in many developed economies. Those lockdowns adversely impacted the global supply chain throughout all the steps, and demand shifted. These lockdowns also included travel restrictions and closing restaurants, bars, and service providers like hairdressers. Therefore, the manufacturing, hospitality, and service sectors were the most severely hit. Those, and further disruptions of the economy led to a 4.6 percent GDP drop in Germany. In Quarter two, output fell by ten percent, labor by almost nine percent, and investment by 15 percent. Moreover, ex- and imports were reduced by nearly nine percent and more than eight percent. Since the pandemic was not a market failure, the German government stabilized the economy at its pre-pandemic state. To achieve this goal, the government implemented many policies. After presenting those policies, the work at hand used the Business BCA method to understand the state of the economy.

For Germany, the efficiency wedge explains 72% of the variance in output, 75% in hours worked, and 31% in investment. This suggests that, when focusing on output and hours worked, the efficiency wedge is the dominant margin through which the pandemic shock and policies implemented in its aftermath, impacted the economy. This can be explained by the extensive lockdowns which prevented existing production factors such as labor and capital, from producing at their full potential and thus reflect productivity losses. Furthermore, the capital provided by the stimulus package was not applied selectively only to profitable companies but to all companies impacted by COVID-19 containment implementations. It helped zombie companies to keep running. For this reason, the capital was invested inefficiently, and the transfers kept the workers from losing the current occupation and transfering to a more productive job, thus impacting the labor factor. This suggests that indeed, to the extent in which there was no significant job destruction, the lockdowns are well identified as major drivers of

the fall in economic activity. Their end would predict a sharp recovery in output and hours worked, as observed previously in 2008 and 2009.

The government's decisive action and massive involvement during the outbreak of COVID-19 prevented many companies from declaring bankruptcy through the stimulus package, kept unemployment low through short-time work, and avoided poverty through cash transfers. However, this was only possible because of the economy's strength and the credibility of investors. Still, Germany's debt to GDP ratio has increased tremendously from 58 to 68 percent in just one year, according to Eurostat (Eurostat 2021). Furthermore, the virus keeps on mutating, and at the end of 2021, many companies are still dependent on government support, and the German state's debt keeps increasing. While, the government creates more tax revenues when the economy recovers quickly. The economic cost of companies closing and rising unemployment might exceed the costs of keeping the government spending high.

Additionally, quarter four of the output and hours worked simulation showed that both variables started to follow a path between the efficiency and labor wedge. This observation might be due to an increasing unemployment rate and number of insolvencies. This development needs to be focused on by future research, and it remains crucial to keep track of the state of the economy in this crisis no matter how long it will last.

Limitations of this research must be pointed out. First, BCA is not a method to find one specific model. However, it supports researchers developing quantitative models of economic fluctuations to allow the models to produce business cycle fluctuations comparable to those in the data. Therefore, it will not present the perfect model to capture all fluctuations but suggests a limited number. The researchers then must pick the one model that explains the fluctuations best. Furthermore, other shocks - like Brexit in January 2020 - that had an impact on Germany's im- and exports were excluded since it is believed that the COVID-19 crisis impact is more significant than the shocks of those other events.

7. References

Aguiar-Conraria, L., Brinca, P., Guðjónsson, H. V., & Soares, M. J. (2017). Business cycle synchronization across US states. The BE Journal of Macroeconomics, 17(1).

Anderton, Robert, Vasco Botelho, Agostino Consolo, António Dias Da Silva, Claudia Foroni, and Matthias Mohr. 2021. "The Impact of the COVID-19 Pandemic on the Euro Area Labour Market," January. https://www.ecb.europa.eu/pub/economic-bulletin/articles/2021/html/ecb.ebart202008_02~bc749d90e7.en.html.

Balta, Narcissa, Ismael Valdes Fernandez, and Eric Ruscher. 2013. "Assessing the Impact of Uncertainty on Consumption and Investment." *Quarterly Report on the Euro Area (QREA)* 12 (2): 7–16.

Baqaee, David, and Emmanuel Farhi. 2020. "Supply and Demand in Disaggregated Keynesian Economies with an Application to the Covid-19 Crisis." Working Paper 27152. Working Paper Series. National Bureau of Economic Research. https://doi.org/10.3386/w27152.

Bernanke, Ben S. 1983. "Irreversibility, Uncertainty, and Cyclical Investment*." *The Quarterly Journal of Economics* 98 (1): 85–106. https://doi.org/10.2307/1885568.

Bofinger, Peter, Sebastian Dullien, Gabriel Felbermayr, Clemens Fuest, Michael Hüther, Jens Südekum, and Beatrice Weder di Mauro. 2020. "Economic Implications of the COVID-19 Crisis for Germany and Economic Policy Measures." In *18 Economic Implications of the COVID-19 Crisis for Germany and Economic Policy Measures*, 167.

Boone, Laurence. 2020. "Trackling the Fallout from COVID-19." In *Economics in the Time of COVID-19*.

Bosen, Ralf, and Jens Thurau. 2021. "Chronologie: Ausbreitung des Coronavirus in Deutschland | DW | 23.06.2021." DW.COM. June 23, 2021. https://www.dw.com/de/chronologie-ausbreitung-des-coronavirus-in-deutschland/a-58003172.

Brinca, Pedro. 2013. “Monetary Business Cycle Accounting for Sweden.” *The B.E. Journal of Macroeconomics* 13 (1).

https://econpapers.repec.org/article/bpjbejmac/v_3a13_3ay_3a2013_3ai_3a1_3ap_3a35_3an_3a29.htm.

———. 2014. “Distortions in the Neoclassical Growth Model: A Cross-Country Analysis.” *Journal of Economic Dynamics and Control* 47 (October): 1–19. https://doi.org/10.1016/j.jedc.2014.07.013.

Brinca, Pedro, V. V. Chari, Patrick J. Kehoe, and Ellen McGrattan. 2016. “Accounting for Business Cycles.” Working Paper 22663. Working Paper Series. National Bureau of Economic Research. https://doi.org/10.3386/w22663.

Brinca, Pedro, and João Costa-Filho. 2021. “Economic Depression in Brazil: The 2014-2016 Fall.” MPRA Paper. April 20, 2021. https://mpra.ub.uni-muenchen.de/107298/.

Brinca, Pedro, and Costa-Filho João. 2021. “Output Falls and the International Transmission of Crises.” MPRA Paper. April 20, 2021. https://mpra.ub.uni-muenchen.de/107297/.

Brinca, Pedro; Duarte, João Bernardo and Miguel Faria-e-Castro.2021."Measuring labor supply and demand shocks during COVID-19". European Economic Review, 139, 103901.

Brinca, P., Iskrev, N., & Loria, F. (2022). On identification issues in business cycle accounting models. Advances in Econometrics, Essays in Honor of Fabio Canova, (forthcoming).

Caceres, Carlos, Mai Chi Dao, and Aiko Mineshima. 2021. “Beyond the Pandemic: Five Charts on Germany’s Economic Recovery Plan.” IMF. July 15, 2021. https://www.imf.org/en/News/Articles/2021/07/13/na071521-beyond-the-pandemic-five-charts-on-germanys-economic-recovery-plan.

Camous, Antoine, and Grégory Claeys. 2020. “The Evolution of European Economic Institutions during the COVID-19 Crisis.” *European Policy Analysis* 6 (2): 328–41. https://doi.org/10.1002/epa2.1100.

Clemens, Marius, Geraldine Dany-Knedlik, Simon Junker, Claus Michelsen, and Werner Röger. 2021. "DIW Berlin: Mehrwertsteuersenkung hat deutsche Wirtschaft im Corona-Jahr 2020 gestützt." Text. DIW Berlin. 2021. https://www.diw.de/de/diw_01.c.817849.de/publikationen/diw_aktuell/2021_0062/mehrwertsteuersenkung_hat_deutsche_wirtschaft_im_corona-jahr_2020_gestuetzt.html.

Dorn, Florian, Clemens Fuest, and Florian Neumeier. 2020. "After the Great Economic Collapse: Germany's Stimulus Package to Recover the Economy in Times of Covid-19." July 2020. https://www.cesifo.org/en/publikationen/2020/article-journal/after-great-economic-collapse-germanys-stimulus-package-recover.

Eurostat. 2021. "File:Public Balance and General Government Debt, 2017-2020 ([1]) (% of GDP) Oct 2021.Png." October 21, 2021. https://ec.europa.eu/eurostat/statistics-explained/index.php?title=File:Public_balance_and_general_government_debt,_2017-2020_(%C2%B9)_(%25_of_GDP)_Oct_2021.png.

Federal Statistic Office. 2021. "Business Notifications, Insolvencies." Federal Statistical Office. November 2021. https://www.destatis.de/EN/Themes/Economic-Sectors-Enterprises/Enterprises/Business-Notifications-Insolvencies/_node.html.

Felbermayr, Gabriel, Julian Hinz, and Hendrik Mahlkow. 2020. "Deutschlands Wirtschaft seit dem Corona-Lockdown." Research Report Spezial Corona-Update 1. Kiel Policy Brief. https://www.econstor.eu/handle/10419/216908.

Merkel, Angela. 2020. Pressekonferenz von Bundeskanzlerin Merkel zu Maßnahmen der Bundesregierung im Zusammenhang mit dem CoronavirusRede. https://www.bundeskanzlerin.de/bkin-de/aktuelles/pressekonferenz-von-bundeskanzlerin-merkel-zu-massnahmen-der-bundesregierung-im-zusammenhang-mit-dem-coronavirus-1731022.

OECD. 2020. *OECD Economic Outlook, Interim Report September 2020*. Paris: Organisation for Economic Co-operation and Development. https://www.oecd-ilibrary.org/economics/oecd-economic-outlook/volume-2020/issue-1_34ffc900-en.

Personio. 2020. "Kurzarbeit: Die wichtigsten Fakten." *Personio* (blog). April 6, 2020. https://www.personio.de/hr-lexikon/kurzarbeit/.

Pusch, Toralf, and Hartmut Seifert. 2020. "Kurzarbeit in der Corona-Krise mit neuen Schwerpunkten." September 2020. https://www.boeckler.de/de/faust-detail.htm%3Fsync_id=HBS-007876.

Scholz, Olaf, and Peter Altmaier. 2020. Corona-Schutzschild: Pressekonferenz mit Olaf Scholz zu Milliarden-Hilfen der Bundesregierung - Bundesfinanzministerium - Service. https://bundesfinanzministerium.de/Content/DE/Video/2020/2020-03-13-corona-bundesregierung/2020-03-13-corona-bundesregierung.html.

Schultze, and Braun. 2021. "Corona: Insolvenzantragspflicht wird ausgesetzt." Schultze & Braun. 2021. https://www.schultze-braun.de/leistungen/corona/insolvenzantragspflicht/.

Šustek, Roman. 2010. "Monetary Aggregates and the Business Cycle." *Journal of Monetary Economics* 57 (4): 451–65. https://doi.org/10.1016/j.jmoneco.2010.03.003.

Taylor, John B., and Harald Uhlig. 2016. *Handbook of Macroeconomics. Volume 2A*. Handbooks in Economics 15. Amsterdam: Elsevier.

Van Der Putten, Raymond. 2020. "Supply chains after Covid-19." Newsletter BNP Paribas. economic-research.bnpparibas.com. July 8, 2020. http://economic-research.bnpparibas.com/html/en-US/Supply-chains-Covid-19-7/8/2020,39146?docid=39146.

Welle, Deutsche. 2021. "Germany's 2020 Exports Slumped 9.3% as Pandemic Batters Trade | DW | 09.02.2021." DW.COM. February 9, 2021. https://www.dw.com/en/germanys-2020-exports-slumped-93-as-pandemic-batters-trade/a-56506934.

WHO. 2020. "Coronavirus Disease 2019 (COVID-19): Situation Report 100." Geneva.

Wollmershäuser, Timo, Marcell Göttert, Christian Grimme, Carla Krolage, Stefan Lautenbacher, Robert Lehmann, Sebastian Link, et al. 2020. “ifo Konjunkturprognose Sommer 2020: Deutsche Wirtschaft – es geht wieder aufwärts.” *ifo Schnelldienst* 73 (Sonderausgabe): 3–58.

Xu, Zhitao, Adel Elomri, Laoucine Kerbache, and Abdelfatteh El Omri. 2020. “Impacts of COVID-19 on Global Supply Chains: Facts and Perspectives.” *IEEE Engineering Management Review* 48 (3): 153–66. https://doi.org/10.1109/EMR.2020.3018420.