75th Economic Policy Panel Meeting

7- 8 April 2022

NeigCovid-Induced School Closures in the US and Germany: Long-Term Distributional Efhbourhood stigma and place-based policies

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Covid-Induced School Closures in the US and Germany: Long-Term Distributional Effects

March 7, 2022

Abstract

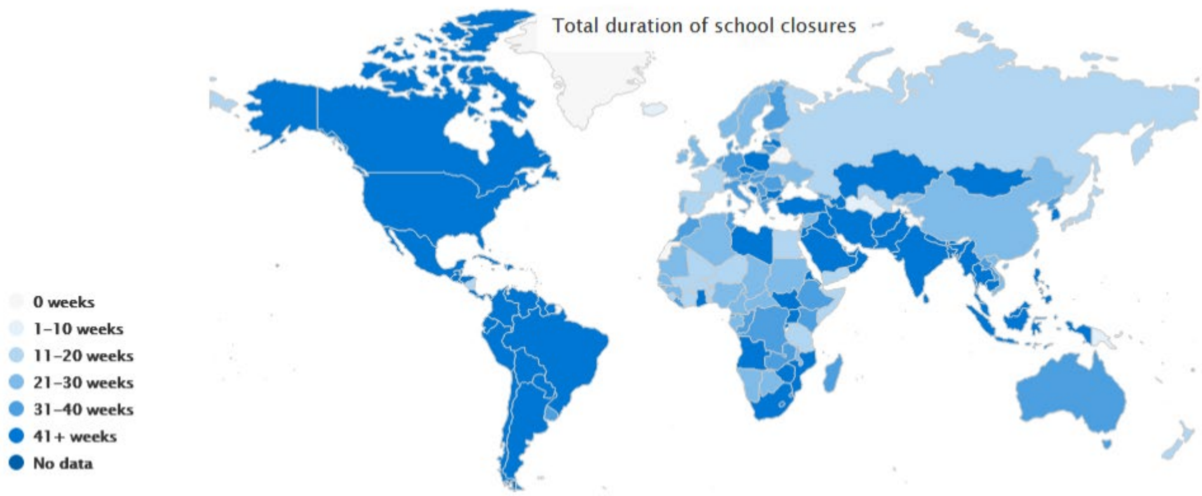
Almost all countries worldwide closed schools at the outbreak of the Covid-19 crisis. I document that schooling time dropped on average by -55% in the US and -45% in Germany from the onset of the crisis to the summer of 2021. In the US, schools were closed longer in richer than in poorer areas, while in Germany the regional variation is much smaller. However, Germany exhibited substantial variation by grade level, with a strong U-shaped patterns that implies that children attending middle school faced the longest closures. A structural model of human capital accumulation predicts that the US school closures on average lead to a reduction of life-time earnings of –1.7% for the affected children. While the overall losses are likely somewhat smaller in Germany, the socio-economic gradient in the losses could be larger than in the US, leading to increased inequality and decreased intergenerational mobility.

1. Introduction

The Covid-19 pandemic forced governments worldwide to restrict certain activities to prevent the spread of the virus. Next to many other sectors of the economy, one sector affected by these measures everywhere worldwide were schools. Figure 1 shows UNESCO estimates of the total duration of full or partial school closures from the start of the crisis at the beginning of 2020 to October 2021 for all countries worldwide. On average over all countries, schools were closed partly or fully for 35 weeks. According to the UNESCO data, the Americas were the continent with the most extensive school closures, but school closures were also substantial in parts of Africa and Asia. Within Europe, schools were closed longer in the Eastern part than in the Western part.

[1] I thank my co-authors Dirk Krueger, André Kurmann, Etienne Lalé, Alexander Ludwig, and Irina Popova for the productive joint work on which part of this paper builds. I thank Jakob Kalb, Lara Klein, Franziska Riepl, and Teresa Schildmann for excellent research assistance, and William Cannon Warren for generating the maps of Germany. Financial support by the ERC through Consolidator Grant No. 815378 and by the DFG through a Gottfried Wilhelm Leibniz-Preis is gratefully acknowledged.

Fig. 1: Total duration of full and partial school closures worldwide



Source: UNESCO

Clearly, the UNESCO data are a coarse approximation of the actual extent of school closures, given that there was a lot of heterogeneity of the closures *within* countries. This heterogeneity encompassed regional variation, variation by grade level, variation by public vs. private schools, etc. For the US, the UNESCO indicates 62 weeks of partial school closures, but none of full closures. For Germany, the UNESCO indicates 24 weeks of partial closures, and 14 weeks of full closures, for a total of 38 weeks of school closures. Together with Austria and Italy, Germany is the country with the longest school closures in Western Europe. In France, for example, school closures summed up to only 12 weeks (7 full and 5 partial), less than a third of the German closures, in Spain to 15 weeks (10 full and 5 partial). However, it remains unclear how to aggregate partial and full school closures, how much variation there within the category of partial school closures, and in general how these numbers are constructed given the considerable heterogeneity in closures within countries.

In this paper, I provide detailed estimates of school closures in the US and Germany based on granular data on the school level in the US, and on the county/grade level in Germany. Thus, these data provide actual estimates of lost schooling time, and also take into account partial closures, i.e. periods in which only part of the children attended schools. Based on these data, on average schools were closed longer in the US than in Germany, but the difference is smaller than in the UNESCO data. On average, US students experienced a drop in school visits of -55%, and German students of –45% in the period from the start of the crisis in March 2020 to the summer of 2021.

I also document two sets of heterogeneity. In the US, schools in richer areas were closed for a substantially longer period than schools in poorer areas. Kurmann and Lalé (2021) show that this can be attributed to a lower Republican voter share and stronger teacher unions. In Germany, the regional variation in school closures is in general much smaller than in the US, and no such clear pattern emerges. Regarding the grade level of the school, in the US school closure lengths are monotonically increasing in the age of the children, being shortest in elementary schools and longest in high schools. In Germany, on the other hand, they exhibit a strong U-shaped pattern: the shortest closures arise for the children in the last years of the highest track high schools, followed by children in elementary school. Children aged 11 to 16 experienced the longest closures

I then introduce a two generations life-cycle model to generate an estimate of the long-term losses of the school closures for the affected children. The model comes from Fuchs-Schündeln et al. (2021), and features at its core a human capital production function of children. To accumulate human capital, children receive monetary and time inputs from their parents, but also schooling inputs coming either from public or private schools. We calibrate the model to pre-crisis data for the US, and use it as a laboratory to analyze the long-term consequences of the school closures on the children, allowing for endogenous reactions by both parents and children to the school closures. The model is thus intended to capture the cost of the school closures, but has nothing to say about the benefits.

The model predicts that, on average, the children in the US affected by the school closures will experience a long-term earnings drop of -1.7%, and a welfare drop of -1%. Summing the decrease in gross earnings up over all children and discounting it to today, the earnings drop corresponds to -2.4% of the US pre-crisis GDP. Thus, the school closures constitute a significant additional cost of the Covid crisis, which however will only arise in the future. The model also predicts substantial heterogeneity in the costs of the closures among children: younger children and children coming from disadvantaged households experience higher losses than older ones or children coming from well-off households. Parental reactions to the school closures are strong and matter for the children, and well-off parents have more means at hand to support their children. Relying on insights from the model and the empirical evidence gathered in the first part of the paper, I hypothesize that the socio-economic gradient of the school closures might be larger in Germany than in the US, given that the school closures are more homogeneous by parental characteristics in Germany than in the US. The U-shaped age pattern of the closures in Germany should lead to a stronger age pattern in the losses: it assigns the largest losses to children in middle schools, and minimizes the losses of the oldest students, for whom human capital accumulation plays less of a role anyhow. Moreover, these oldest students come disproportionately from well-off households, again steepening the socio-economic gradient.

If governments want to counteract the losses of the children, they should increase schooling time, and they should do it immediately. A reasonable policy of extending schools in the US for 6 weeks in the 2 summers after the crisis largely pays for itself.

The remainder of the paper is structured as follows. Section 2 gives an overview of the literature on the Covid-induced school closures. Section 3 then explains the school closure regulations in the US and Germany, introduces the data, and compares the empirical patterns of the school closures in the US and Germany. Section 4 introduces the model and presents the model results, while Section 5 draws policy implications from the model. The last section concludes.

2. Literature on the Covid School Closures

There is by now a growing literature on the Covid-19 induced school closures. Within the field of economics, this literature is however still quite small. While there are probably dozens of economics papers incorporating the SIR model into a macroeconomic model to analyze the causes of the Covid-19 recession, there are few papers in economics focusing on the Covid-19 school closures.

There are only a handful papers analyzing the consequences of the school closures based on structural models. Besides the two papers by Fuchs-Schündeln et al. (2021) and Fuchs-Schündeln et al. (2022), on which this paper builds, the paper by Jang and Yum (2020) analyzes the long-run economic and welfare consequences of the school closures, focusing on intergenerational mobility and allowing for general equilibrium effects. Agostinelli et al. (2020) zoom in on high school students, and model an additional channel for losses from school closures that goes beyond a direct loss of school instruction time, namely the change in peers generated by school closures. They find that the loss of a socially diverse group of peers, as schools provide, is detrimental to the learning outcomes of children from disadvantaged households. While all these papers focus on the US, Samaniego et al. (2022) model school closures worldwide. They provide evidence that lost schooling time was most extensive in the middle income countries. Despite this fact, they find that the school closures affect the welfare of individuals in the high income countries most negatively, because schooling plays a much more important role in these countries.

While medium- to long-term effects of the school closures can only be assessed via structural models, there is some evidence emerging on the short-run effects of the closures on children's test scores. These studies partly also try to get at the question of the effectiveness of online teaching. An early study by Engzell et al. (2021) points towards a high ineffectiveness of online learning. It analyzes test score changes of Dutch students in the spring of 2020, and compares them to test score changes over the same months in previous years. The authors conclude that, on average, the learning loss of children was as large as if no teaching had occurred at all, despite substantial online teaching. The two review studies by Hammerstein et al. (2021) and König et al. (2022) similarly find that online learning at the start of the crisis did not prevent extensive learning loss, with some indication, however, that the effectiveness of online learning increased over time as teachers and students got used to it. A recent study by Halloran et al. (2021) relies on test score data from 12 US states and finds that full in-person instruction is significantly more effective than virtual or hybrid instruction.

This literature also finds large heterogeneity in the effects of school closures, with children from disadvantaged households suffering most from a lack of in-person instruction. This is e.g. the case both in the studies by Halloran et al. (2021) and Engzell et al. (2021), and the finding is in line with evidence of less usage of online teaching tools among children from disadvantaged households in the US (Bacher-Hicks et al., 2021; Chetty et al., 2021). Based on survey data from Germany, Grewenig et al. (2021) document that on average students cut their time spent on schooling by roughly half during the spring of 2020, and that the decrease was significantly larger for low-achievers than for high-achievers. The same survey reveals that more than half of the children had online teaching less than once per week during the period of full school closures (Woessmann et al., 2020). Even by the spring of 2021, almost 40% of the children had online teaching with the entire class at most once per week (Woessmann et al., 2021). Thus, the extent of online teaching seems to have been quite limited in Germany, but there is no strong heterogeneity in its usage by parental background, in contrast to the US. The second survey also asks parents about participation of their children in voluntary support measures offered by schools, e.g. free tutoring or free summer courses. It finds that, in fact, children of college-educated parents are more likely to participate in such measures than children of non-college educated parents (Woessmann et al., 2021).

Apart from the evidence on learning losses of children induced by the school closures, there is also evidence on negative effects of the closures on children's mental and physical health (see, e.g., Viner et al., 2021, and Chaabane et al., 2021, for two review studies). What remains contentious is the effect of school closures on the spread of the pandemic (see Tan, 2021, for an overview). There seems to be a consensus emerging that school closures might have been effective in preventing the spread of Covid-19, but that their effect was rather small. In the specific context of Germany, von Bismarck-Osten (2022) find no effect of school closures on infection rates among children or adults.

3. School Closures in the US and Germany

3.1. Regulations and Data

At the outbreak of the Corona crisis in March 2020, 44 states in the United States ordered public school closures, while the rest recommended them at some point during March. 23 of the states also mandated the school closures of private schools (Zviedrite et al, 2020). School closures during this initial period were thus quite universal.

However, in the school year 2020/21, the decision to close schools rested largely with school districts, of which there are more than 13,400 in the US.[2] Only 15 states had state-wide closure orders in place at some point during the school year 2020/21, and some states mandated minimum times that school had to be open (Ballotpedia, 2022). School districts sometimes decided in a differentiated way for primary schools, middle schools, and high schools. Private schools were not subject to the regulation of the public school districts.

Given that the decision process was so decentralized in the US for most of the crisis, it is hard to collect systematic evidence on the school closures based on public regulation, and for private schools one necessarily has to collect the evidence school by school. The evidence presented herein thus comes from data on actual school visits presented in Fuchs-Schündeln et al. (2021). I describe the basic procedure for generating the data here, and refer the interested reader to the detailed description in Fuchs-Schündeln et al. (2021). To calculate school closures, we rely on Safegraph data on cell-phone visits (in minute time intervals) at the physical location of a specific school on the weekly level. The extent of the closure of a specific school is then basically determined by the drop in cell phone usage at the physical location of the school on a typical school day, and is a continuous variable. Specifically, we construct changes in cell-phone visits relative to the average visits prior to the pandemic, taking account for trends in cell phone usage. We combine these data with the Department of Education's National Center for Education Statistics (NCES) to gain further insights on the type of school. This results in about 102,500 high-quality matches of schools with Safegraph data on visits. [3]

In Germany, school closures were determined based on clear public regulations. The decision bodies regarding school closures were the 16 state governments, and private schools were subject to the same regulations as public schools. While there were substantial efforts of coordination between the states, the state governments were free to decide on their own, which they did in irregular intervals. An exception to this was the period from April 23 to June 30, 2021, during which the "Bundesnotbremse", a federal law which I discuss below, was in place. Thus, I construct the data on the extent of school closures based on these regulations. I first describe the regulations, and then how I construct concrete school closure data on the county level based on the regulations.

All states differentiated between grade levels in their regulations, often distinguishing between roughly four groups: grade levels 1 to 4 (i.e. children in primary school), grade levels 5 and 6 (i.e. children roughly of age 11 and 12), grade levels 7 to 10 (or in some cases 11), and the final one to two grade levels before obtaining the university entrance degree ("Abitur") in the highest track ("Gymnasium", or the highest track of "Gesamtschule"). The university entrance degree is a combination of the grades obtained in the last two years of schooling plus final examinations at the end of the last school year. In all states the last grade level (either grade level 12 or 13) had special rules applied to it, and in some states also the second to last grade level. Moreover, children who went to the two lower tracks of the German school system ("Hauptschule" and "Realschule", plus the associated tracks in "Gesamtschulen") get their final school-leaving degree after grade levels 9 and 10, and in that case these final grade levels also had special rules applied to them ("Abschlussklassen").

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[2] This refers to the school year 2018/2019 (see Number of public school districts and public and private elementary and secondary schools: Selected years, 1869-70 through 2018-19).

[3] In Fuchs-Schündeln et al. (2021), we further combine the Safegraph data with data by Burbio to construct effective learning times. Here, in parallel to the German data, I report results relating exclusively to the percent drop in schooling time constructed from Safegraph data. See also Kurmann and Lalé (2021) for further information on effective in-person learning time in the US.

The German-wide school closures started on March 16, 2020. States decided between four modes of schooling: fully open schools, rotating schooling ("Wechselunterricht"), fully closed schools (either with or without digital schooling in place), and suspension of obligatory physical presence. Rotating schooling means that only part of each class comes to school every day, and different groups rotate either on a daily or weekly basis. Suspension of obligatory physical presence means the temporary permission of home schooling, which is usually forbidden in Germany. Thus, students can come to school, but do not have to.

In the period from April 23 to June 30, 2021, there was a federal law in place ("Bundesnotbremsegesetz") that specified that schools in counties with an incidence over 100 (measured as the 7-day average of confirmed daily Covid-cases per 100,000 inhabitants) had to implement rotating schooling, and schools in counties with an incidence over 165 had to close.[4] The states were free to implement even stricter measures, and sometimes did, but could not relax these rules except for the graduating grade levels. Thus, all variation within one grade level on the county level comes strictly from this time period; otherwise, there is only variation on the state level. There are 401 counties in Germany.

Based on these state and federal regulations, I code up the lost schooling per each individual grade level (1 to 12 or 13) in each county for each regular school day from March 16, 2020, to the summer of 2021.[5] I.e., all observations are on the county-grade level. The percent drop in schooling time on a specific school day is set to -100% if schools were closed, and 0% if schools were open. I set it to -50% if there was a rotating scheme in place. This is an optimistic value, since in many cases classes were split into three rather than two groups, and thus children were schooled a third rather than half of the usual days.[6] The category "suspension of obligatory physical presence" applies to only 2.32% of the grade-county-day observations. It is coded as -100%, as in practice parents were discouraged to send their children to school during these days. For grade levels 9 and 10, I calculate school closures as the weighted average of classes that received their final school leaving degree ("Abschlussklassen") and regular classes.[7] For grade levels 11, 12, and 13, I proceed state by state. For each state, I first determine whether the highest school leaving degree is obtained after 12 or 13 years of schooling.[8] I then apply the state rules that relate to the last or second-to-last years of schooling respectively.[9]

To build Germany- or state-wide averages, I first calculate the average school closures over all grade levels on the county level, and then build population-weighted averages, relying on total population counts of the Federal Statistical Office.

[4] Specifically, schools had to implement these forms of schooling three days after the county-level incidence increased above the threshold level, and could recur to more physical schooling five days after the county-level incidence fell below the respective threshold level.

[5] One county with an early outbreak (Heinsberg) closed schools already from February 26, 2020, onwards. Another county (Worms) closed schools two school days before the general closures, i.e. on March 12 and 13. For these two counties, the observation period starts with the first day of school closures.

[6] In the case of very small classes, students could still come in every day, but this was rare.

[7] The weights on the Abschlussklassen are 11% for grade level 9, and 51% for grade level 10, calculated based on data about student counts per grade level by the Federal Statistical Office.

[8] For states in which schools can decide between both options, I determine what applies to the majority of students, and then assign the entire state to this system. This is again based on data on student counts per grade level by the Federal Statistical Office. Bremen, Hesse, Niedersachsen, and Rhineland-Palatia are assigned 13 years of schooling, all other states 12 years of schooling.

[9] Most states also had less extensive closures for the last grade level of primary schools. That is grade level 4 in most states, but grade level 6 in Berlin and Brandenburg.

3.2. Extent of School Closures in the US and Germany

In this section, I describe and compare the extent of school closures for the US and Germany, as well the regional heterogeneity. For both countries, I start the observation period with the first school closures in March. For the US, the observation period ends in May 2021, given that summer holidays typically start in June. For Germany, the observation period runs up to the start of the summer vacation in 2021, which is somewhat different in each state, but always lies between late June and early August.[10]

As Table 1 shows, for the US the average schooling time decreased by -55.1% over the period March 2020 to May 2021. Thus, the average student in the US attended school less than half the usual times during these roughly 1.25 school years, which constitutes a dramatic drop in schooling. Among public schools, schooling time on average decreased by -56%, among private schools, whose share is smaller, by -46% (see Fuchs-Schündeln et al., 2021).

Table 1: Average Drop in Schooling Time

	US	Germany
Total time period		
March 2020 – Summer 2021	-55.1%	-44.9%
Subperiods		
March 2020 – Summer 2020	-88.5%	-70.1%
Summer 2020 - Dec 2020	-54.3%	-5.7%
Jan 2021 – Summer 2021	-40.7%	-58.0%

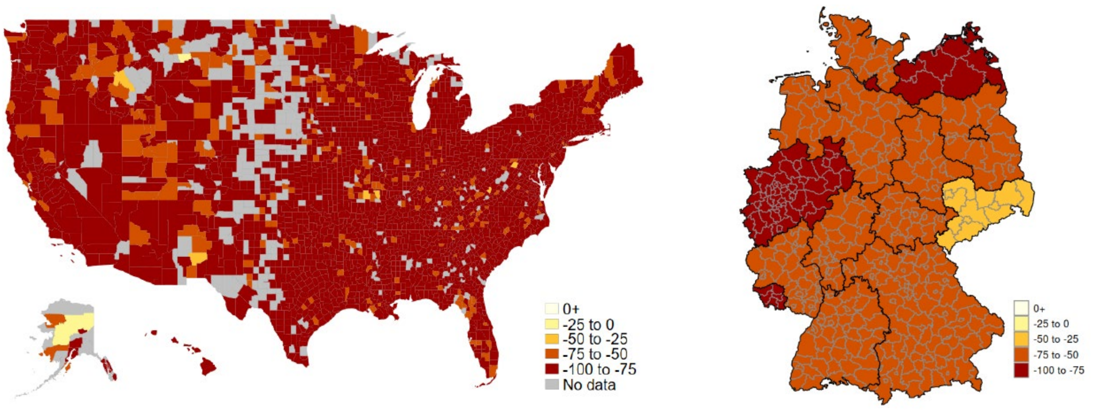
Source: The numbers for the US come from Fuchs-Schündeln et al., 2021, and are calculated based on Table 2 therein. For Germany, the numbers come from own data collection.

For Germany, I estimate a drop in schooling time of on average -44.9% (see Table 1). Thus, our data confirm that on average school closures were more extensive in the US than in Germany. Yet, even in Germany, children went to school on average just slightly more than half the usual times during these 1.25 school years. Thus, the difference in our data, where Germany's school closures are at 81% of the US value, is substantially smaller than the difference in the UNESCO data, where Germany's school closures are at 61% of the US value. This shows that it is very important to explicitly account for full vs. partial school closures, and also for the intensive margin within the category of partial school closures, in order to generate comparisons across countries or even within countries among regions or grade levels. In order to translate our estimates in "weeks closed", the measure the UNESCO applies, I have to make several assumptions. First, I assume that the observation period covers 1.25 school years. Secondly, I assume 190 days of schooling in Germany and 180 days of schooling in the US in a typical school year. The -55.1% drop in schooling then corresponds to 25 weeks of full closures in the US (1.25*180*0.551/5), while the German drop of -44.9% corresponds to 21 weeks of full closures.

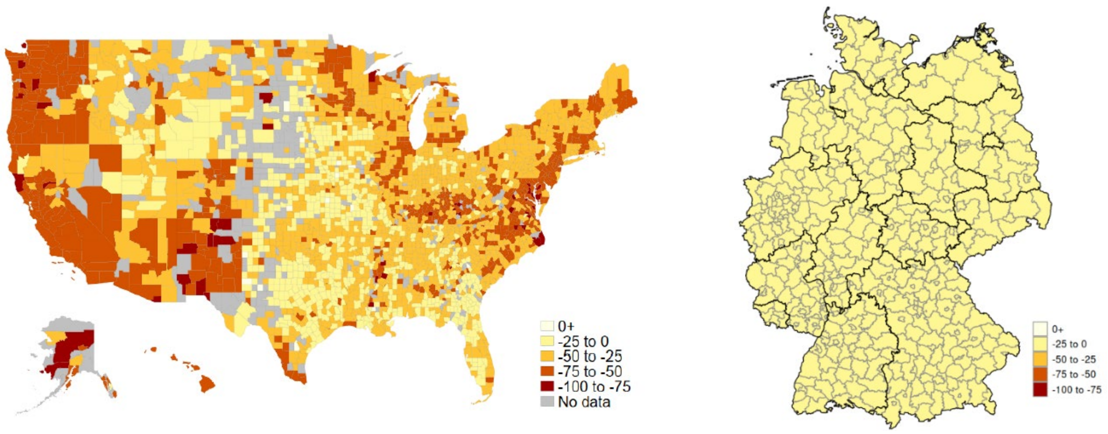
[10] In the fall of 2021 and early spring of 2022, schools were largely open in both countries, with few local exceptions. However, newspaper reports point to partial schooling in the US to some degree.

Figure 2: School Closures in the US (left) and Germany (right)

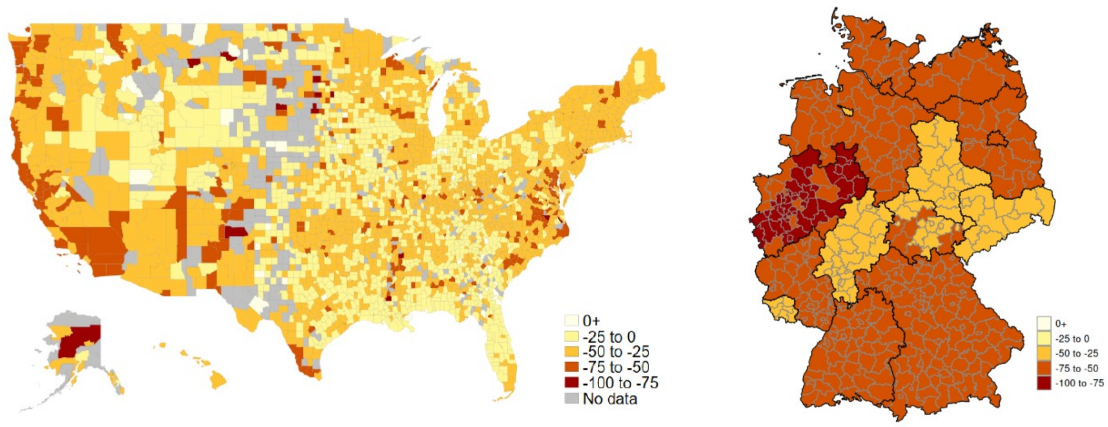
a) March to start of summer vacation 2020



b) End of summer vacation to December 2020



c) January to start of summer vacation 2021



Source: Left panel on the US: Fuchs-Schündeln et al. (2021), Figures 2 to 4; Right panel on Germany: own data collection

Figure 2 shows the percentage of schooling time lost by county in the US and Germany in three time periods: March to start of summer vacation 2020 (panel A), end of summer vacation to December 2020 (panel B), and January to start of summer vacation 2021 (panel C). As the left side of panel A shows, schools were closed almost entirely from March to May 2020 in most US counties; on average schooling time decreased by -88.5% during that time period in the US (see Table 1). In the fall of 2020, especially counties on the East or West coast still experienced decreases in schooling time of -50 to -75%, while in a sizeable number of counties especially in the center of the US schooling time decreased by less than -25%. Thus, in this time period there is significant regional variation in the US. On average, schooling time dropped by -54.3%. In the spring of 2021, the process of opening schools continued, with the same pattern of more extensive closures at the coasts than in the center of the country. On average the drop in schooling time still amounted to -40.7% (see Table 1).

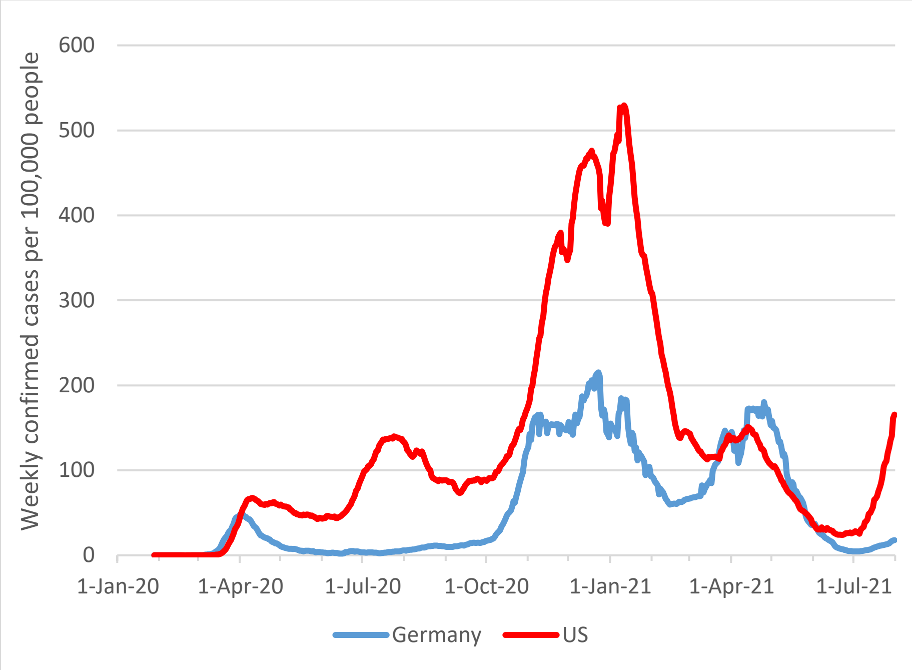
As in the US, schools in Germany were closed to a large extent everywhere at the start of the crisis, with an average decline in schooling time of -70.1% (see Table 1). The smaller average decrease in Germany than in the US during this time period can largely be explained by the later start of the summer vacation in Germany: schools started slowly opening up again in May 2020, when the US school year already drew to an end. A stark contrast between the US and Germany arises in the fall of 2020: while schools were still closed to a significant extent in the US during that time period, schools were largely open everywhere in Germany in the fall of 2020, with average school closures of just -5.7%.[11] In the spring of 2021, however, Germany experienced substantially more extensive school closures than the US. On average, schooling time in the first half of 2021 dropped by -58% in Germany, while in the US the loss in schooling time was on average -40.7%.[12] Thus, while in the US the extent of school closures gradually decreased over time, in Germany we see a clear temporal hump-shaped pattern. The different patterns can only partly be explained with different Covid-19 rates, as Figure 3 shows. The US was hit harder by the first Covid wave in the spring of 2020, and continued with significantly higher numbers than Germany in the fall of 2020, when Germany opened up schools to a large extent. However, the Covid incidences in both countries are roughly equal in the spring of 2021, which makes it hard to explain the substantially stronger school closures in Germany during that time period. Of course, we only observe the Covid case numbers conditional on implementing all government-imposed measures, not the counterfactual numbers without any governmental intervention. Still, it seems that the time-series of the Covid incidence might matter in decision making: while being comparable in absolute levels, the Covid incidence in the US was low in spring 2021 compared to the fall 2020, while the opposite was true in Germany.

Given the more centralized decision process on the state level, Germany experienced substantially less regional heterogeneity in the school closures than the US. The right part of Figure 2 clearly shows the minimal variation in the length of school closures within states, which only applies to the period of spring 2021, when the federal law was in place. Even across state borders, the variation is smaller than in the US.

[11] The county with the most extensive school closures during that period, Berchtesgadener Land, had a drop in schooling time of -19.9%, followed by Hildburghausen with -11.1%. The counties with the least closures experienced a drop of only -2.4%, concentrated in the days before the winter break.

[12] The drop varied between -79% to -29% across counties in Germany during that time period.

Figure 3: Covid-19 Incidence in US and Germany, 2020 to Summer 2021



Note: This figure shows weekly new confirmed cases per 100,000 people in Germany and the US. Source: Own calculations based on Covid case numbers from the Johns Hopkins University Center for Systems Science and Engineering and population data from Macrotrends.

3.3. Heterogeneity in School Closures by Grade Level and Income

3.3.1. Heterogeneity by Grade Level

An important source of heterogeneity in school closures arises on the grade level. In the US, school visits dropped by -51% for elementary schools, and -64.4% for secondary schools. Among secondary schools, middle schools are closed for a shorter period than high schools, but the difference between both is rather small (see Kurmann and Lalé, 2021). Thus, in the US the length of school closures is monotonically increasing in the age of the affected children, see Table 2.

Table 2: Loss in Schooling Time by School Type

	US	Germany
Elementary school	-51.0%	-43.4%
Secondary school	-64.4%	-45.6%
Middle school	-62.5%	-51,6%
High school	-66.1%	-36,3%

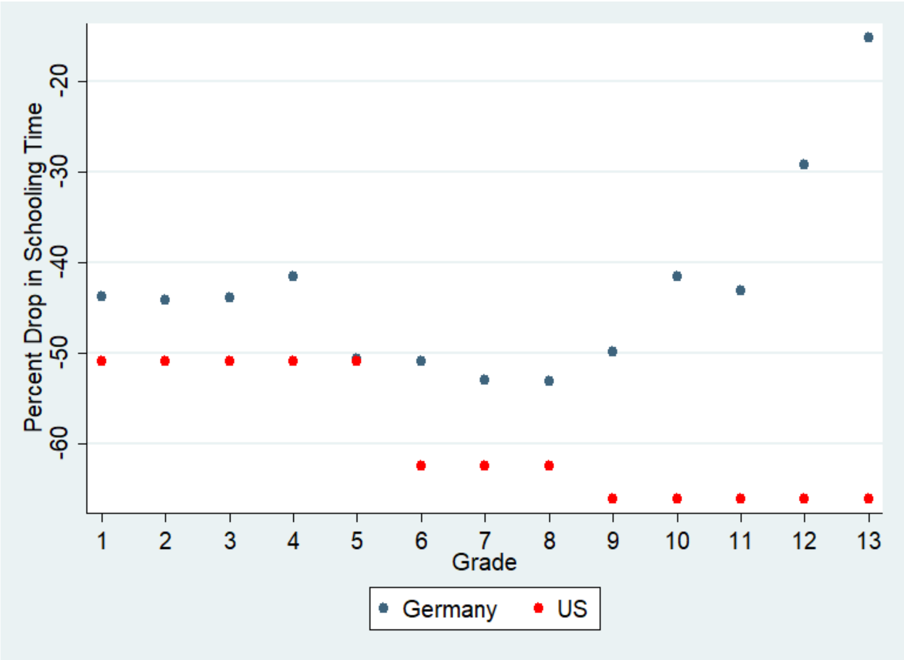
Note: For the US, the values come from Table 3 in Fuchs-Schündeln et al. (2021), combined with information from Kurmann and Lalé, 2001, for middle vs. high schools. The latter refer to public schools only. The assignment of secondary schools to middle vs. high schools is not always possible. For Germany, the data come from the own data collection.

The patterns in Germany resemble the ones in the US only to a certain extent. As Table 2 shows, also in Germany elementary schools were closed shorter than secondary schools, but the difference is very minor with only 2.2 percentage points, compared to 13.4 percentage points in the US. More importantly, this small difference between elementary and secondary schools arises because the length of school closures is not monotonically increasing in age in Germany, but decreasing in age within the secondary schools. Figure 4 shows the variation in average school closures over all grade levels, and depicts the monotonically increasing (in absolute terms) pattern of lost schooling in the US (red), but a strong U-shaped pattern for Germany (blue). Like in the US, school closures were shorter in elementary schools than in the middle grades in Germany.[13] The average German-wide school closure length peaks for grades 7 and 8. Grades 9 and 10 have similar closure lengths for classes that are not in their last year of schooling, but on average feature shorter lengths because classes in their last year of schooling (i.e. in the lowest track or middle track) faced shorter school closures (see Appendix Figure A1, which differentiates between "Abschlussklassen", i.e. the last class before a child leaves school, and regular classes, for the grades to which this applies.)[14] The last two years in the highest track, either grades 11 and 12 or grades 12 and 13, were most protected against school closures. Compared to an average drop in schooling time of -53% for grades 8 and 9, the average drop in grade 12 amounted only to -29%, and in grade 13 to -15%. I.e., the school closures were more than three times longer for children in grades 8 and 9, roughly aged 13 to 14, than for children in grade 13, roughly aged 18. Appendix Figure A2 in addition shows that some states differentiated quite extensively between grade levels, e.g. Northrhine-Westphalia (NRW) and Saxony (SA), while the differences across grades were substantially smaller in other states, e.g. Schleswig-Holstein (SH), Hamburg (HH), Lower Saxony (NS), and Bavaria (BAY).

[13] Within elementary schools, school closures were shortest for grade 4, since many states decided to also shorten the closures in this last grade of elementary school. However, on average the differences were small, with closures around -44% for grade 1 to 3, and -41.6% for grade level 4. For Berlin and Brandenburg, the last grade in elementary school is grade 6, and closures were also slightly shorter there. Berlin is the only state that also had shorter closures in grade 1.

[14] For the second to last grades in the upper level, there were special rules in place, which correspond to the black spot for grade 12 in states with 13 grade levels, and the dot "11G8" in states with 12 grade levels in Appendix Figure A1.

Figure 4: Average School Closure Length by Grade Level in Germany and the US



Note: Data come from Fuchs-Schündeln et al. (2021) and Kurmann and Lalé (2021) for the US. We can only differentiate between elementary, middle, and high schools, and assign grades 6 to 8 to middle schools in the graph. Data for Germany come from own data collection.

Summarizing, in the US school closure lengths were increasing in the age of the children, while in Germany there is a strong U-shaped pattern with shorter closures for the youngest and especially the oldest children. I will come back to this important difference when discussing the results of the structural model, which clearly indicates that, given the same length of closures, the negative long-term effects are decreasing in the age of the child.

3.3.2. Heterogeneity by Income

Figure 2 displays substantial regional variation in school closures in the US, while for Germany this is less the case. Does the regional variation correlate with regional characteristics? Table 2 shows the loss in schooling time in counties belonging to the top vs. bottom quartiles of the income distribution in the US and Germany, respectively.

Table 3: Loss in Schooling Time by Regional Income

	US	**Germany**
Top income quartile	-61.4%	-46.0%
Bottom income quartile	-48.7%	-42.1%

Note: For the US, the values come from Table 3 in Fuchs-Schündeln et al. (2021). Regional income is measured as US mean household income from the American Community Service. For Germany, regional income is measured as county-level GDP per capita from Eurostat.

In the US, there is systematic variation of the length of school closures with regional income: regions belonging to the bottom quartile of the income distribution experienced substantially shorter school closures than richer regions, with a difference of 13 percentage points in the percent of schooling time lost. As Kurmann and Lalé (2021) document, schools in states with Republican governors or a higher Republican vote share have on average shorter closure durations, and schools in counties with higher teacher unionization rates have longer closures. These characteristics drive the correlation with regional income. Thus, partly the regional variation in school closures is driven by voters' political preferences, with Republicans in general implementing less stringent policies to combat Covid, partly by negotiation power of teachers.

The variation by income in Germany goes qualitatively in the same direction as in the US, but is quantitatively much smaller: the difference in the drop of schooling time amounts to only less than 4 percentage points between the counties belonging to the top or bottom quartile of the income distribution. As Figure 2 shows, schools were on average closed for a slightly shorter period in the East German states, which are on average poorer. The strong correlation between political preferences and school closure duration featured in the US does not seem to be present in Germany. However, the East German states are also the ones with the highest vote share for the far right party Alternative for Germany, which largely opposes stringent anti-Covid measures.[15]

4. A Structural Model of School Closures

As stated in the literature review, there are by now first papers analyzing the immediate effects of the Covid school closures on test scores (see, e.g., Halloran et al., 2021). To assess the long-term effects of the school closures on labor earnings and welfare of the affected children, one has basically three options: first, in a few years, once the affected first children entered the labor market, we can start analyzing medium-term effects empirically. This option will not be available for some time, however. Secondly, we can extrapolate expected labor market effects from empirical studies. This is the route taken for example by Woessmann (2020), who concludes that the loss of one third of a school year should approximately translate into long-term earnings losses of 3 to 4 percent, based on empirical estimates that an additional year of schooling raises long-term earnings by approximately 10 percent. Yet, these studies do not capture the unexpected event of school closures during the school year, but rather focus on extended schooling at the end of the schooling career. There are also empirical studies that analyze the short-run effects of schooling time on test scores, e.g. Carlsson et al. (2015). Closest to analyzing more substantial school closures is a study by Jaume and Willén (2019), who find that the accumulated loss of half a year of schooling in elementary school due to frequent teacher strikes in Argentina decreases long-term earnings by 3 to 4 percent. What is problematic about extrapolating from these studies is that they analyze short interruptions, which are likely associated with different parental responses than the prolongued school closures due to Covid-19.

A third option to study the long-term effects of the school closures is to build a structural model of human capital accumulation with public and private inputs, and to then simulate the school closures within this model, and in the following I will present results based on this approach. The advantage of this approach is that one can predict long-term outcomes, taking into account endogenous responses of children and parents to the substantial school closure shock. The disadvantage is that in any structural model, we have to make assumptions about functional forms, and we have to calibrate

[15] Formally investigating a correlation is difficult, given that one essentially has only 16 state observations to work with. Yet, in any case the regional variation is much smaller than in the US.

parameters matching moments from the data. The results are likely sensitive to these assumptions and calibrated parameters.

4.1. The Model

The details of the model I present here can be found in Fuchs-Schündeln et al. (2021). We build a two generations life cycle model, in which the economy is populated by the current parents and the current children, and we follow both generations until the end of their life cycle. I sketch the main set-up of the model here, and hint at the most important calibration facts.

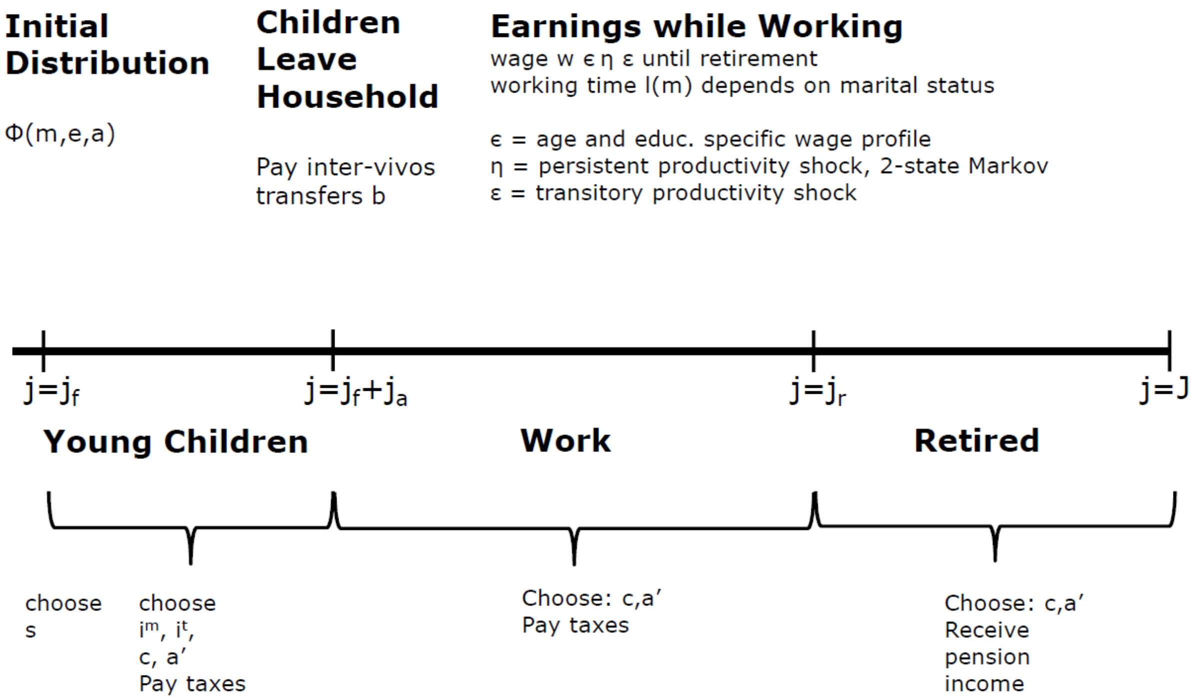
4.1.1. The Parental Generation

Figure 4 shows the life cycle of the parent generation. Given that the focus of the model lies on the school closures, we model the current parental generation from the moment they have children onwards, which we denote with the age j_f. Parents in the model differ along three dimensions, namely martial status (m), education (e), and assets (a), and we take their joint distribution along these three dimensions at age j_f directly from the data. The number of children per parental household is also taken from the data, taking into account heterogeneity along these three dimensions. The life cycle of the parents can be divided into three periods, namely a first period in which they work and have children in their household, a second period in which they continue working but children have left the household, and a third period in which the parents are retired. During all three periods, parents face a standard consumption-saving decision (c vs. a'), either receive labor earnings or pension income, and pay taxes.

For our purpose, the most interesting period of the parental life cycle is the first one, during which parents take decisions regarding investment into their children. First, the parents decide whether to send the children to private or public school (schooling choice s). Private schools require tuition payments by the parents, while public schools are free. On the positive side, private schools are more productive in schooling the children than public schools, i.e., the same time spent in a private school rather than a public school increases human capital of the children by more. After deciding on the school type, during every period the parents decide how much money (i^m) and how much time (i^t) to invest into their children. When the children turn adult (at child age j_a and thus parental age j_f+j_a), the parents can leave inter-vivos transfers (b) to their children, which the children can use to pay college tuition, or simply to save or consume. Parents have an incentive to invest into their children because they care about them (though less than about themselves): the life-time utility of the children enters the parental utility function when children leave the household.

The labor earnings of the parents exhibit a standard age-education specific wage profile, and are subject to both transitory and permanent shocks. We set working time exogenously, but allow it to vary by marital status, such that single parental households have lower earnings on average than married parental households.

Figure 5: Life Cycle of the Parent Generation



Source: Figure 5a from Fuchs-Schündeln et al. (2021)

4.1.2. The Child Generation

The life cycle of the child generation is depicted in Figure 5. It is divided into five periods. The first period of childhood is the one during which parents take all decisions for their children (this period ends at age j_a when children turn adult). This period is followed by two periods in which children potentially graduate from high school and from college. After that, children work and eventually retire.[16]

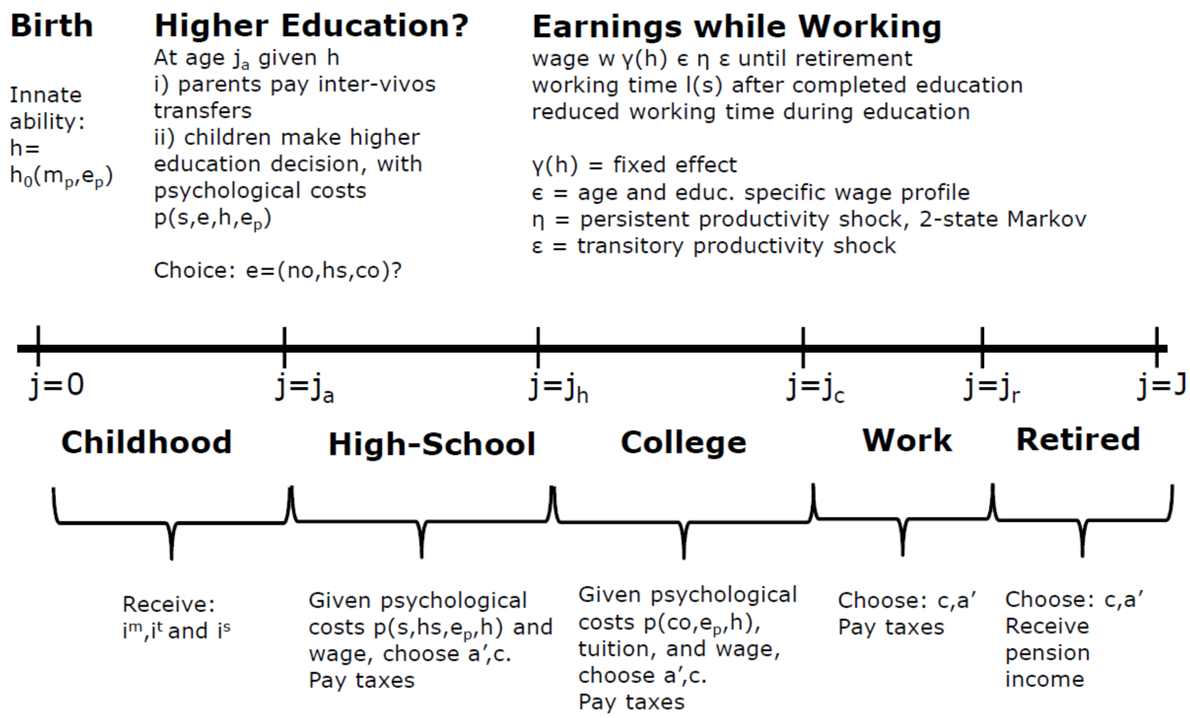
Children enter the economy with an initial human capital (h_0), which depends on the characteristics of their parents through nature. During their childhood, children do not take any decisions, but accumulate human capital based on the monetary and time inputs they receive from their parents (i^m and i^t), as well as the input they receive from their school (i^s), which can be either a private or a public school. Thus, children arrive at adulthood (at age j_a) with a certain human capital stock, and at this point in time also receive inter-vivos transfers from their parents (b). From that point onwards, they live on their own and take all decisions on their own. Like the parental generation, they receive earnings while working and pension income when retired, and face a standard consumption-savings choice in each period.

When children turn adult, they have to decide whether to drop out of high school and start working immediately (e=no), to graduate from high school (e=hs), or to even go on and graduate from college (e=co). Attending both high school and college is associated with a psychological cost (p) that depends on the own human capital (h), the education of the parent (e_p), and in case of high school also on the type of school (s). Thereby, we capture the facts that, conditional on human capital, children of more

[16] Since we only model two generations and do not set up a complete overlapping generations model, we assume all children are single and do not have children on their own.

educated parents are more likely to complete schooling and attend college, and high school drop-out rates are lower in private schools. Attending college is in addition associated with monetary tuition costs. While in high school or college, members of the child generation do work as well, but work lower hours than the members of the child generation who decided to drop out of school. The labor earnings of the child generation resemble the one of the parent generation, with one difference: the children face the same age-education specific wage profiles as well as income shock processes, but in addition they have a fixed effect in their earnings profile that depends on their human capital. Thus, human capital leads to higher earnings through two channels: first, it increases the incentives to invest in higher education by lowering the psychological costs of higher education; second, even within an education group, those with higher human capital have higher earnings.

Figure 6: Life Cycle of the Children Generation



Source: Figure 5b from Fuchs-Schündeln et al. (2021)

4.1.3. The Human Capital Production Function

At the core of the model, there is a human capital production function that features two important attributes in line with the literature on human capital accumulation (see especially Cunha and Heckman, 2007), namely self-productivity and dynamic complementarity. Self-productivity of human capital means that future human capital is increasing in today's human capital. This is a standard feature of any form of capital, which captures an accumulated stock. Related to human capital, it essentially implies that learnings builds on itself. An important implication of this feature is that a learning loss early in childhood has stronger negative consequences than the same learning loss later in childhood, given that it makes future learning more difficult, and there is more future learning to come for smaller children.

Dynamic complementarity of human capital means that any investment in human capital is more productive the higher the initial stock of human capital. This is in stark contrast to the usual assumption of decreasing marginal returns. It implies that parents of children with higher human capital have higher incentives to invest into their children, amplifying any initial inequalities. It also implies that, given a loss of human capital, parents will optimally decrease their future investment into children.

We model the human capital production function as a nested function with three layers. The innermost layer combines parental time and monetary investment into total parental inputs. The middle layer combines parental inputs and schooling inputs into one investment input. Finally, the outermost layer combines the stock of human capital and the investment input into human capital next period. Each layer is associated with an elasticity of substitution and age-specific weights on the two input factors.

4.1.4. Calibration to US Data

We calibrate the model to US data before the Covid crisis, using a two year frequency. Some parameters, e.g. those associated with the exogenous income process, are estimated exogenously in a first step, while many parameters – especially preference parameters - are calibrated within the model. Our most important data source, which we use for parental characteristics and the earnings processes, is the PSID. Based on test scores of young children in the Child Development Supplement (CDS) of the PSID, we can determine initial human capital of children based on parental characteristics, and find that initial human capital is increasing in the education of the parent, and is on average higher for children of married parents than for children of single parents.[17] The CDS also provides information on time and monetary investment of parents into their children. While the former is strongly decreasing in the age of the child, the latter is rather flat. We use test score and wage data of young adults in the NLSY to calibrate how human capital translates into earnings depending on the educational level. The slope in this relationship is increasing in education, giving a further incentive to increase human capital at the top of the human capital distribution.

Regarding the human capital production function, we set the elasticity of substitution between human capital and investment in the outermost layer and between parental time and monetary investment in the innermost layer equal to 1, based on the literature (Cunha et al., 2010, and Lee and Seshadri, 2019). The crucial elasticity between parental investment and schooling investment is set equal to 2.43 based on Kotera and Seshadri (2017). Thus, schooling and parental investment are substitutes, but far from perfect ones. The age-specific weights on the relative input factors are set to match age-specific parental investment profiles. The calibrated weights imply that for younger children, time investment carries more weight than monetary investment by the parents, while the opposite is true for older children. Moreover, the stock of human capital becomes a more important determinant of next period's human capital the older the child, i.e. the impact of investment on next period's human capital is decreasing in the age of the child. All details can be found in Fuchs-Schündeln et al. (2021).

4.1.5. Modeling the Covid-Induced School Closures

After we calibrate the model, children in the model are hit by the unexpected school closures due to the Covid-19 pandemic. The school closure affect the children at different model ages. The extent of the shock is set according to the data and exhibits the heterogeneity documented in Sections 3.2 and

[17] The earliest age for which test scores are available is the age of 3 to 5. We thus model children from age 4 onwards, and take their human capital at that age as exogenous. Essentially, the human capital at age 4 is the result of a mixture of nature and nurture in the first years.

3.3 above: Secondary schools are closed longer than elementary schools, public schools longer than private schools, and schools attended by children of richer parents longer than schools attended by children of poorer parents.[18] Implicitly, we assume zero effectiveness of online teaching. As discussed in Section 2, online teaching was likely not very effective, and probably exacerbated any socio-economic gradient in losses.

In the model, both parents and children optimally adjust their behavior once the schooling shock hits. Parents change their investment into the children not only in the period of the shock, but also in future periods, as well as their future inter-vivos transfers. Children adjust their future education decisions.

4.2. Model Results: Long-Term Effects of the School Closures

4.2.2. Average Effects

Table 4 shows the average model predicted effects of the Covid-19 school closures on the affected children, averaging over all age groups and all parental characteristics. On average, the model predicted share of college graduates will fall by 1.9 percentage points, while the share of high school dropouts will increase by 1.6 percentage points due to the school closures. While these sound like modest effects, they correspond to a relative increase in the number of high school drop outs of 12.7%, and a fall in the number of college graduates of 5.7%. Thus, on average the school closures will lead to a substantial worsening of the highest educational attainment for the affected cohorts.

The lower final educational attainment is the outcome of an optimal decision of the children that is based on their lower human capital: on average, they arrive at age 16, when they make their final educational decisions, with a human capital that is 2.8% lower than it would have been in the absence of the school closures. Due to the lower educational attainment, combined with the lower human capital, the long-term earnings of the children fall by -1.7%. This means that the children affected by the school closures will earn 1.7% less year after year over their entire working life than they would have earned in absence of the school closures. While this might not sound dramatic, it implies that the aggregate effect of the school closures is large and economically important: summing this up over all affected children and discounting it to today, this sum corresponds to -2.4% of the US pre-crisis GDP (see Fuchs-Schündeln et al., 2022).[19] The school closures are thus a substantial additional economic cost of the Covid pandemic that is not experienced in the short run, but over the longer term. Translating the earnings loss into a welfare effect, we find that the welfare of the affected children on average decreases by 1% when calculated as the consumption equivalent variation.

[18] While we document this heterogeneity with respect to regional income in the data, we apply it with respect to parental income in the model.

[19] In Fuchs-Schündeln et al. (2022), we assume somewhat longer school closures. The empirically documented school closures in Fuchs-Schündeln et al. (2021) correspond to 80% of the assumed ones in Fuchs-Schündeln et al. (2022), thus I report here 80% of the GDP-loss calculated in Fuchs-Schündeln et al. (2022).

Table 4: Model Results on Average Long-Run Implications of School Closures

	Baseline	School Closure Effect
		Change
Share s=no	12.2%	+1.6 pp
Share s=hs	54.6%	+0.4 pp
Share s=co	33.2%	-1.9 pp
		Change
Average HK	1.00	-2.8%
PDV gross earnings	$845,150	-1.7%
Child CEV	-	-1%

Note: Based on Table 14 in Fuchs-Schündeln et al. (2021).

Note that these losses suffered by the children arise despite substantial increases in investment by the parents: parents increase their time and monetary investment into the children substantially during the time period of the school closures, and also increase their final inter-vivos transfers to the children. Without this additional investment of the parent, the welfare losses of the children would be roughly 30% larger (see Fuchs-Schündeln et al., 2022). The endogenous responses are thus an important reason why we might find somewhat smaller long-term effects of the school closures than the ones based on extrapolation of previous empirical results presented at the start of Section 4.

4.2.3. Distributional Effects

Table 5 presents distributional effects of the Covid-induced school losses, concentrating on the final welfare effect. The first dimension of heterogeneity is the age of the child. As the table shows, the welfare losses of children of age 6 are roughly 30% larger than the welfare losses of children of age 14. This is the fact *despite* shorter closures for younger children. This result comes from the self-productivity of human capital: any initial loss in human capital becomes larger over time, and this effect plays out for many years for young children. In Fuchs-Schündeln et al. (2022), we document that an initial loss of human capital of approximately -2% for a child of age 6 roughly doubles by age 14, always compared to a situation without school closures. With homogeneous lengths of school closures, this translates to welfare losses that are monotonically decreasing in age. Taking into account the longer closures in secondary schools, we find that children at the start of secondary school, i.e. at age 10, experience even slightly larger welfare losses than children at age 6; they have a CEV of -1.17%.

Table 5: Distributional Model-Based Welfare Effects of School Closures

Heterogeneity Dimension	School Closure Effect	
By age		
	Age 6	Age 14
	-1.14%	-0.86%
By parental income		
	Top quartile	Bottom quartile
	-0.57%	-1.11%
By school type		
	Private school	Public school
	-0.64%	-1.04%

Note: Based on Tables 14, 17, and 19 in Fuchs-Schündeln et al., 2021

The second dimension of heterogeneity is parental income. We find that the welfare losses of children from parental households belonging to the bottom quartile of the income distribution are roughly twice as large as the welfare losses of children from parental households belonging to the top quartile. This is the result of two countervailing effects: richer parents increase their investment into their children much more after the school closures than poorer parents. However, children from richer parents also on average face longer school closures, see Table 2. This actually buffers the socio-economic gradient somewhat: with homogeneous length of school closures, the losses of children in the bottom quartile would be almost 2.5 times as large as the one of children in the top quartile.

The third dimension of heterogeneity is the school type. Our model predicts that children in public schools experience welfare losses of -1.04%, while children in private schools have welfare losses of "only" -0.64%. Here, two effects are going in the same direction. First, there is a selection effect: children in private schools come on average from richer households, and thus their parents can increase their investment into the children by more during the school closures. Secondly, schooling time in private schools decreased by -46%, compared to -56% in public schools, as I document above. Both effects together lead to the substantially higher welfare losses of children attending public schools rather than private schools.

Summarizing, the model finds that especially young children from poor households experienced substantial welfare losses from the school closures.[20] Obviously, the welfare of children from poorer households is on average lower even without the school closures. In addition, parental income is not the only source of variation that matters in the welfare effects: parental education and parental assets are also important, and all three dimensions are highly correlated in the data. In Fuchs-Schündeln et al. (2022), we document that – under the assumption of school closures of equal length – the welfare losses of children coming from parental households with the worst characteristics (belonging to the bottom quartile of the income distribution, bottom quintile of the asset distribution, and in which parents are high-school drop-outs) suffer welfare losses that are 4 times as large as children from the

[20] Appendix Table A1 shows the distributional effects on gross earnings rather than welfare. The socio-economic gradient in earnings is somewhat smaller than in welfare, because well-off parents additionally protect the welfare of their children by increased inter-vivos transfers. The gradient in the age effect is similar between earnings and welfare.

most privileged households. Thus, the school closures are likely to significantly exacerbate the socio-economic gradient in the US.

4.3. Discussion of the German School Closures in Light of the Model Results

We do not apply the model directly to Germany, because we lack data on parental inputs into the children for Germany, which are crucial data for the calibration of the parameters. Still, I want to draw four tentative conclusions from the model results on the effect of the school closures in Germany. These are admittedly somewhat speculative and mostly qualitatively, but can nevertheless give some insights into the expected effects.

First, the somewhat shorter average school closures in Germany than in the US (-44.9% vs. -55.1%, see Table 1) should lead to on average somewhat lower long-term losses for the affected children in Germany than in the US. Moreover, parents could potentially increase their time investment into children more easily in Germany than in the US during the school closures: on average, married women aged 25 to 54 worked roughly 350 annual hours less in Germany than in the US before the Covid crisis.[21] This large difference is driven by the much higher degree of part-time work in Germany than in the US, not by differences in the employment rate. Part-time work makes it easier to increase the time investment into the children. This is a second factor that points towards lower average welfare losses for the children in Germany than in the US.

Second, the model predicts that younger children experience more significant long-term losses from the school closures than older children. Thus, to minimize the welfare losses, it is optimal to close schools longer for older children. This policy was followed in the US, but not in Germany. The length of school closures increased between elementary school and middle-school grades, but children in grades 11 to 13 were quite shielded from the school closures, as Figure 4 shows. The reason for this is the importance of these grades for the university entrance exam. Still, children of this age group suffer least from the school closures conditional on homogeneous closure length, and thus protecting them further makes the age-gradient in the losses likely stronger in Germany than in the US. Moreover, this policy likely also has a negative impact on the socioeconomic gradient of the losses: children in the highest track come disproportionally from well-off families (see, e.g., Statistisches Bundesamt, 2019, and Dodin et al., 2022).

Third, the model implies a substantial gradient in losses with parental characteristics. In the US, as a counteracting force, schools were closed longer in richer areas than in poorer areas. That is less the case in Germany (see Table 3), which could exacerbate this gradient. For private vs. public schools, the opposite is the case: both types of schools were subject to the same regulations in Germany, while private schools were closed for a shorter period than public schools in the US. This works towards lowering the gradient, but in both countries only around 10% of the children attend private schools. Thus, regarding the socio-economic gradient, the more homogeneous school closures and the shorter closures for children in the highest track in Germany point towards a stronger socio-economic gradient in Germany and the US, and are together likely stronger than the countervailing effect regarding a smaller difference between private and public schools in Germany. A big unknown when it comes to the socio-economic gradient remains the gradient in parental inputs in Germany vs. the US, which could then also matter for the adjustment to the school closures. In Fuchs-Schündeln et al. (2022), we document a substantial gradient in parental monetary investments into children by parental

[21] This is calculated based on data from the Current Population Survey and the European Labor Force Survey in 2016.

education, and a smaller gradient in parental time investment, but we lack comparable data for Germany.

Fourth, discrete educational decisions matter in the model: a significant part of the lower long-term earnings of children in the model comes from their lower final educational attainment, see Table 4. In Germany, the decisions to finish high school or not and to attend college or not come at roughly the same age as in the US, but both have smaller impacts on earnings than in the US, given the strong vocational system in Germany (see e.g. Fuchs-Schündeln et al., 2010, and Heathcote et al., 2010, for comparable measures of the college wage premium in Germany and the US). This points towards a lower variance of the losses in Germany than in the US. However, there exists an additional discrete decision during the early schooling years: the German tracking system puts students into different tracks at roughly age 10, with only the highest track leading to 12 or 13 years of schooling and the university entrance degree, while the lower tracks are associated with 9 or 10 years of schooling. This earlier tracking could exacerbate the variance of the long-term losses for children in elementary school. It could also increase the socio-economic gradient, given that the parental background of the children significantly affects their ultimate track assignment (see, e.g., Schneider, 2011, and Scharf et al., 2020). However, Dustmann et al. (2017) find that tracking effects are temporary and do not lead to long-term labor income differences. This seems to be the case because of substantial up- and downgrading during the remaining school years. Thus, it might be the case that the overall variance in the school closure effects is somewhat smaller in Germany than in the US.

Summarizing, I hypothesize that the average welfare losses are smaller in Germany than in the US with also a somewhat smaller variance of the losses. However, the different school closure policies suggest that the age gradient and also the socio-economic gradient in the losses could both be larger in Germany than in the US.

5. Policy Implications

I want to end with policy implications, and focus here on policy lessons for the future, not on the question whether school closures were an effective and cost-efficient way to combat the Covid pandemic in the first place. Given that school closures happened, what should the governments do now to help the children?

The model clearly shows that the school closures are associated with substantial welfare losses for the affected children. If governments want to buffer these losses, they should increase schooling time after the crisis. The model has a few clear messages regarding these increased governmental investments into schooling. First, they should be done as soon as possible. Again, this is due to the self-productivity of human capital: the earlier human capital is increased, the larger is the effect. Secondly, if governments want to target their support, they should target it towards younger children and children from more disadvantaged backgrounds, since these children suffered most from the school closures.

In Fuchs-Schündeln et al. (2021), we analyze the consequences of keeping schools open for an additional 6 weeks in each of the two summers following the period of the school closures in the US. We find that this policy would lower the welfare losses of the children on average by one fifth. Thus, while this is not enough to completely counteract the welfare losses, it is a small step in the right direction. Interestingly, this policy would pay for itself: the costs of extended schooling are completely offset by the net present value of the increased government revenues caused by higher future earnings and thus higher future tax payments. As expected, especially children from poorer households benefit from the policy. Yet, the policy does not pay for itself if only schooling for poor households gets extended: the additional tax revenues through higher earnings accrue mostly from the children of richer households.

A policy lesson that does not come out of the model, but is based on the findings in Woessmann et al. (2021), is that it might be necessary to increase schooling time in an obligatory way to combat the negative *distributional* effects of the school closures, rather than relying on offering voluntary support measures. The voluntary support measures offered in Germany, like additional free schooling in the summer vacation or additional free tutoring during the school year, were taken up more by children from more educated parents: 31% of children of college educated parents took advantage of some support in 2021, while only 18% of children of non-college educated parents did. The reason for this disparity remains unclear, but it indicates that, to reach the students who most need support, it would be most effective to increase mandatory schooling time.

6. Conclusion

Extensive school closures negatively affected children all over the globe. While a lot of discussion during the Covid crisis has focused on the direct costs of the crisis to the government budget, to workers, or to businesses, less discussion time has been devoted to the costs for the children affected by the school closures, likely because these costs will only arise in the future. In this paper, I show that the costs associated with the school closures are substantial, and that the school closures increase the importance of parental background for future earnings, thus reducing the equality of opportunity.

I first document the extent of the school closures in the US and Germany. Children in the US lost more than half their regular schooling time on average during the period from spring 2020 to summer of 2021, while children in Germany lost slightly less than half. In the US, school closure lengths were strictly increasing in the age of the child, while Germany's school closures exhibit a strong U-shape pattern in age. Children from poorer regions experienced on average shorter closures in the US, which was much less the case in Germany. A structural model predicts that, on average, children in the US will experience a long-term earnings loss of -1.7%, and a welfare loss of -1%. There is substantial heterogeneity in these losses, with children from more disadvantaged backgrounds experiencing larger losses. While the average losses are likely smaller in Germany, the socio-economic gradient is likely larger. The U-shaped age pattern in the closures in Germany implies that welfare losses were likely very small for the oldest students, and largest for the children starting middle school.

This paper provides an estimate of the welfare losses caused by school closures that come from lost earnings alone. These losses are substantial, and lead to an increase in inequality between children coming from poor vs. well-off households. I do not consider here losses that come from poorer physical or mental health caused by the school closures, which likely also have a strong socio-economic gradient. Overall, the school closures can be expected to lead to a further decrease in intergenerational mobility. Governments should react immediately and strongly if they want to counteract this development.

A few caveats are in order: first, the model is mute about the potential public health benefits of the school closures, it focuses solely on the cost side. Thus, I have nothing to say on the optimality of school closures. Secondly, the model does not incorporate general equilibrium effects or long-run growth effects that are associated with lower human capital. Also, the model predictions depend on the structural assumptions and the calibrated parameters. For example, in Fuchs-Schündeln et al. (2022), we show that a higher elasticity of substitution between governmental and parental inputs is associated with lower average losses, but a stronger socio-economic gradient. Third, the model is set up to capture the US schooling system, and I extrapolate in this paper to derive some hypotheses for the situation in Germany. Yet, conclusions might be quantitatively quite different for lower-income countries. Much more research is needed to cover all these open issues.

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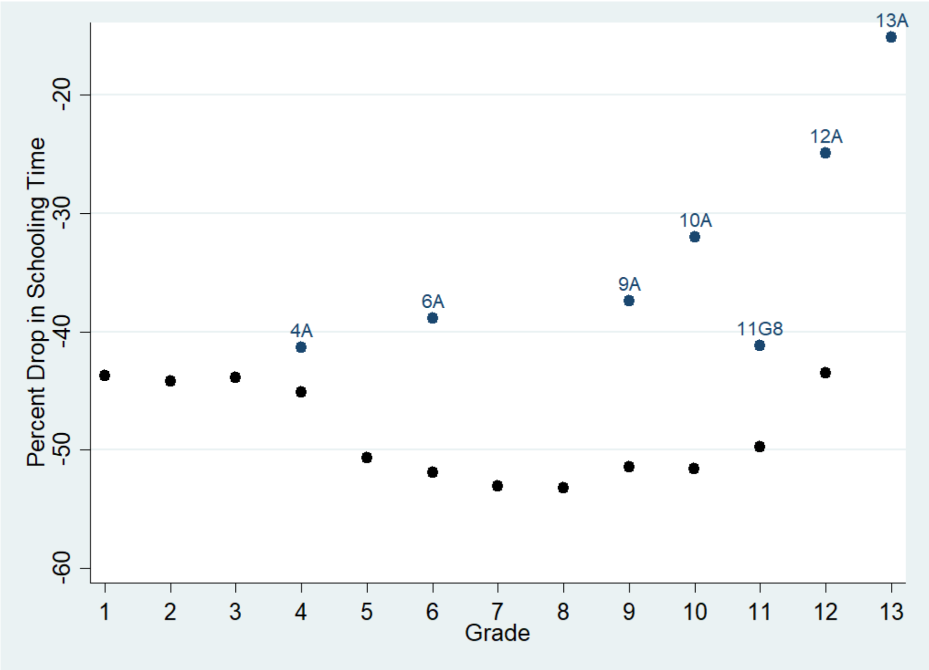
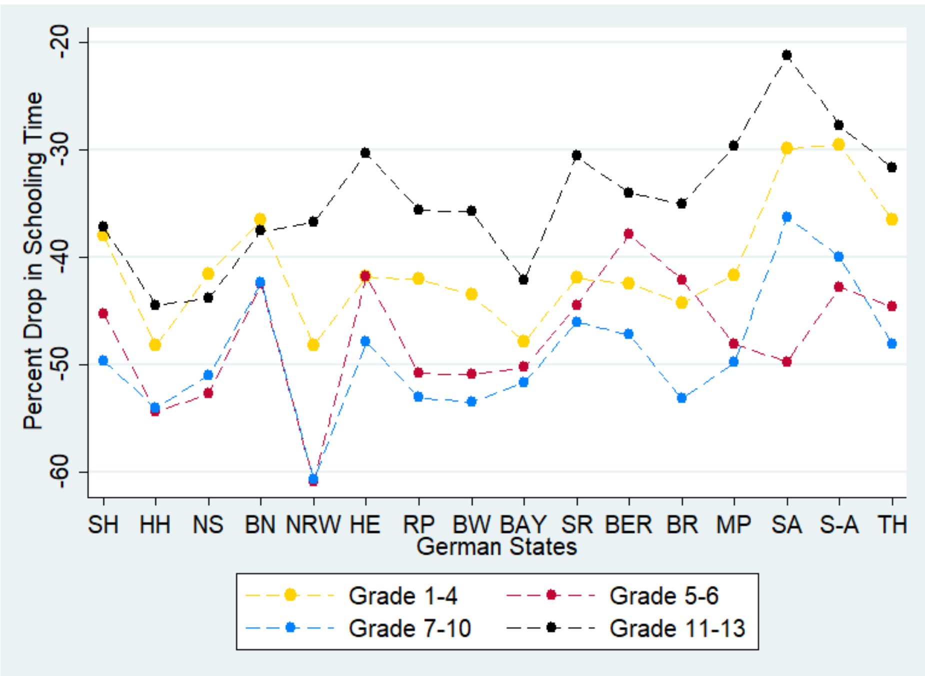
Appendix

Figure A1: Average School Closure Length by Grade Level in Germany, differentiating between classes in last year of schooling ("Abschlussklassen") and regular classes



Note: For some grade levels, there are two dots. The dots denoted with "A" refer to "Abschlussklassen", i.e. they apply to children for whom this is the final year of schooling. The dot "11G8" refers to grade 11 in states in which the final schooling degree is obtained in grade 12. Source: Own data collection.

Figure A2: School Closure Lengths by State and Grade Level in Germany



Source: Own data collection.

Table A1: Distributional Model-Based Earnings Effects of School Closures

Heterogeneity Dimension	**School Closure Effect**	
By age		
	Age 6	Age 14
	-1.97%	-1.50%
By parental income		
	Top quartile	Bottom quartile
	-1.97%	-2.17%
By school type		
	Private school	Public school
	-1.49%	-1.77%

Note: Based on Tables 14, 16, and unreported results in Fuchs-Schündeln et al., 2021