BANK OF ENGLAND

Staff Working Paper No. 943

Did the Covid-19 local lockdowns reduce business activity? Evidence from UK SMEs

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November 2021

This is an updated version of the Staff Working Paper originally published on 15 October 2021

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Did the Covid-19 local lockdowns reduce business activity? Evidence from UK SMEs

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Abstract

This paper analyses the local lockdown measures introduced to contain the spread of Covid-19 in the UK. We use a spatial regression discontinuity design to assess whether the fall in business activity during the lockdowns was driven by the policy measures or by other factors, such as voluntary social distancing. We conclude that the local lockdowns did causally reduce business activity but that activity would have probably fallen substantially even in the absence of the lockdowns. During the local lockdowns, the average turnover growth for SMEs in the UK was around -20%. SMEs that were up to two kilometres inside the lockdown boundaries had 8 percentage points lower turnover growth than those up to two kilometres outside. This implies that the local lockdowns accounted for two fifths of the overall drop in business activity at most. The estimates are largest for restaurants and non-food retail (eg clothes shops), which were directly targeted by the restrictions. Costs fell by much less than turnover, reducing cash flow.

Key words: Covid-19, small and medium-sized enterprises (SMEs), public health measures.

JEL classification: D22, E65, G30.

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ISSN 1749-9135 (on-line)

1 Introduction

1.1 Context

Governments around the world responded to the Covid-19 pandemic by introducing public health measures that were designed to slow the spread of the virus. The UK government implemented a series of lockdowns[1] starting in late-March 2020, which came with measures such as business closures and restrictions on household mixing. These measures remained in place in some form in large parts of the UK until June 2021. Over this period business activity fell substantially, particularly for small and medium enterprises (SMEs)[2], as documented by Hurley et al. [2021]. However, the fact that business activity fell at the same time as the public health measures does not imply that the public health measures *caused* lower business activity, given that the measures and business activity were both responding to the pandemic. This begs the question: Did the Covid-19 lockdowns reduce business activity or would it have fallen even in the absence of the measures? We answer this question using a novel data set with granular information on UK SMEs and conclude that the local lockdown measures did reduce business activity but that activity would likely have fallen substantially anyway.

A simple comparison of the activity of SMEs that were subject to the lockdown measures with those that were not would not identify the causal effect of the lockdown measures.[3] By comparing SMEs that were located very close to either side of the boundaries of local lockdown measures in a regression discontinuity design, we identify the causal impact of the measures on business activity. The results show a drop in turnover growth at the cut-off, with SMEs subject to the local lockdowns facing year on year growth around 8 percentage points lower than unaffected SMEs. During the months that the local lockdowns were in place, average turnover growth for UK SMEs was around -20%, which implies that around half of the overall reduction in turnover growth during the local lockdowns can be attributed

[1] In this paper we use the term 'lockdown' to refer to a range of public health measures that were designed to reduce the spread of Covid-19 in the UK and around the world.

[2] There is no commonly-accepted definition of SMEs. For the purposes of this paper we define them as businesses that have less than £25 million in turnover (another word for revenues).

[3] One obvious reason that this would produce biased results, even controlling for observable SME characteristics, is that SMEs that were subject to lockdown measures were more likely to have customers that were being more severely impacted by the pandemic itself. Indeed, this is one of the reasons why the local lockdown measures were implemented in the first place.

to the public health measures, as opposed to other factors. We repeat the analysis for the tier system and find some evidence for larger reductions in turnover growth for SMEs that were located in the stricter tiers compared to those located in less strict tiers. We focus on the local lockdowns and the tier system because the other public health measures, including the extended lockdowns in Q2 2020 and Q1 2021, were applied at the national level to all UK SMEs at the same time, which means there is no obvious control group for us to use.

It is important to bear in mind that this paper identifies a local average treatment effect of the local lockdown measures on business activity, not the average effect of Covid-19 lockdowns in general. The estimated impact of local lockdowns on business activity could reflect a combination of negative impacts on businesses subject to the local lockdowns and positive impacts on businesses not subject to the local lockdowns, which we refer to as 'spillover effects'. The existence of spillover effects does not invalidate the regression discontinuity design but it does affect the interpretation of the results.[4] In particular, it means that the impacts we estimate in this paper are not necessarily good estimates of the impact of national lockdowns, where these positive spillover effects would not exist.

The paper uses a novel data set that has near-universal coverage of limited company SMEs in the UK. We have data on the monthly cash flows of 2 million UK SMEs that have current accounts with nine major banking groups. Hurley et al. [2021] outlines the features of the data set in significant detail. In this paper we focus on measures of turnover and total costs, based on monthly inflows and outflows into all current accounts held by each business with any of these banking groups. We have information on the precise location of all of the businesses in the data set based on the postcodes[5] they used to register for banking services. Given that the local lockdown measures were applied at local authority level, we use standard local authority shape files to calculate the minimum distance of each business to the boundary of the nearest and strictest set of public health measures. The granularity and size of the data set allows us to compare a large number of businesses across the UK that happen to be located on either side of the boundaries of lockdown measures. For example, in our analysis of the local lockdowns, we compare the activity of 32,000 businesses that are around 2 kilometres outside of the local lockdowns with 30,000 businesses that are around 2 kilometres inside.

[4]See this World Bank blog post for a discussion of this and related issues that often arise in spattial regression discontinuity designs.

[5]Postcodes are the UK equivalent of zipcodes in the United States.

We present a series of robustness checks to confirm the validity of our headline results. We document that the jump in turnover growth at the local lockdown boundaries does not show up if we use placebo boundaries instead. We also show that the results are robust to different choices of bandwidth, although we use a standard optimal bandwidth in our headline results. The only covariate that appears to show a statistically significant discontinuity at the local lockdown boundary is firm age, with SMEs that are located inside local lockdown boundaries younger on average than those just outside. For this reason, we control for firm age in all of our headline results. Nevertheless, as with any regression discontinuity design, the analysis hinges on a number of assumptions: for example, that businesses could not move their premises in the short term to get around the measures and that businesses either side of local lockdown boundaries had similar observed and unobserved characteristics before the pandemic.

1.2 Related literature

A number of papers document large negative impacts of lockdown measures on Covid-19 infection rates. Laydon et al. [2020] use a Bayesian hierarchical model to estimate that the Tier 2 and Tier 3 lockdowns in the UK reduce the R rate by 6% and 23% respectively, concluding that interventions at least as strict as Tier 3 were needed across 90% of the country to suppress the virus. Davies et al. [2020] use an age-structured model to estimate a reduction in the R rate of 2% for areas of the UK subject to Tier 2 and 10% for those in Tier 3. They estimate that the second national lockdown in England implemented in November 2020 reduced the R rate by 22%. Modelling [2020] estimate a 10% reduction in the R rate when moving from Tier 1 to Tier 2 in the UK, although their analysis of Tier 1 is more uncertain. Turning to a more specific public health measure, Courtemanche et al. [2021] use data from Texas in the US to argue that school reopenings increased the number of cases and fatalities.

There is a growing literature on the economic impact of Covid-19 in the UK and around the world, most of which focuses on consumer spending. Hacioglu-Hoke et al. [2021] uses transaction level data from the UK to analyze spending cuts, documenting that the pandemic coincided with a sharp drop relative to the period before, but also that the drop appeared to precede the lockdown measures. A few other papers use transaction data to document

declines in consumption during the height of the pandemic, including Baker et al. [2020] for the US, Carvalho et al. [2020] for Spain and Andersen et al. [2020] for Denmark. In a study that seeks to answer a similar question to the one that we are posing, Gathergood and Guttman-Kenney [2021] uses a difference-in-difference framework to estimate the impact of local lockdowns in the UK on infection rates and real time consumption by analysing comparable cities that were in and out of the local lockdowns. They find that the largest reduction in Covid-19 cases come one month after the local lockdowns but that there is no significant effect of local lockdowns on consumption.

The literature on the impact of Covid-19 on small businesses is smaller, owing to fewer available data sources. Gourinchas et al. [2020] use historical data on a sample of larger SMEs in 17 countries and projects how the pandemic might affect their finances. There is similar analysis for the UK in the Bank of England's August 2020 Financial Stability Report and for Italian firms in Carletti et al. [2020]. Bloom et al. [2021] analyses a survey of small businesses in the US and documents a significant drop in sales that peaked in Q2 2020, which coincides with the stricter lockdown measures. Chetty et al. [2020] uses data acquired from a private sector companies covering business activity and consumer spending. They document the same steep drop in economic activity around the lockdown measures in the US and also exploit the timing of the easing of lockdown measures across US states to argue that they had small impacts on spending and employment. Hurley et al. [2021] introduces the data used in this paper and presents simple regression estimates of the impact of lockdowns on SME turnover growth in the UK. They find that local lockdowns coincide with around a 28 percentage point fall in turnover growth relative to the period before, whilst the tier system coincide with around a 25 percentage point fall, but they do not attempt to assess the causal impact of lockdowns.

There is a vast literature applying regression discontinuity designs to a wide range of policy questions in the social sciences. Cattaneo et al. [2018] summarises the standard approaches and references some of the empirical literature. There are a handful of recent papers that use regression discontinuity designs to study the impacts of Covid-19. Takaku and Yokoyama [2021] analyze school closures in Japan, showing that they reduced child and family well-being by exploiting discontinuities in the probability of being affected by the closures based on age. Brodeur et al. [2021] employ a regression discontinuity design to look into the well-being effects of lockdowns using google trends data in the US and

Western Europe. They use days before and after the lockdown as a running variable, finding significant increases in the search terms for boredom, loneliness, worry and sadness. Dang and Trinh [2020] estimate the impact of lockdowns on air pollution levels in Vietnam and they also use days before and after the lockdown date as their running variable. The most similar papers to ours in terms of methodology are Chakrabarti et al. [2020] and Hansen and Mano [2021], which analyse county-level data in the US around state borders to look at the impacts of mask mandates and Medicaid expansion during Covid. They find that both reduced Covid cases. None of these papers analyze the economic impacts of the pandemic.

The rest of the paper is organized as follows. Section 2 describes the data set and presents some summary statistics. Section 3 sets out the details of the regression discontinuity approach we use to identify the causal effect of the lockdown on business activity. Section 4 presents the results of the analysis for local lockdowns and the tier system. Section 5 runs some standard robustness checks to confirm the validity of the empirical results. Section 6 summarises the conclusions of our analysis.

2 Data

2.1 SME current accounts

We use data on SME current account flows as our main measures of business activity in this paper. The Bank of England receives the data set on a monthly basis via Experian, a private sector information services company. The data set contains information on the total monthly inflows and outflows into all UK SME current accounts that are held with nine major banking groups. It has coverage of 2 million limited company SMEs, which is almost the entire universe in the UK and contains a large number of very small businesses. Hurley et al. [2021] contains more details on the dataset, including on the representativeness of the data and the cleaning process we use to prepare it for cash flow analysis.

We define costs as total current account outflows. The turnover measure takes total current account inflows and strips out any new borrowing we can observe in the data, so that it focuses on the operational performance of each SME.[6] This means for each SME i

[6]Note that both turnover and costs will include the impact of fiscal policy support because we have no way of separating it out in the data.

in month t we compute the following: $turnover_{i,t} = inflows_{i,t} - newloans_{i,t}$. We use this turnover measure to estimate a year on year growth rate, following the approach outlined in Davis et al. [1996], which is often referred to in the literature as the "DHS growth" measure. We calculate the following growth rate for all SMEs, for both turnover and costs:

$$turnovergrowth_{i,t} = \frac{turnover_{i,t} - turnover_{i,t-12}}{\frac{1}{2}(turnover_{i,t} + turnover_{i,t-12})} \tag{1}$$

This growth measure takes into account the intensive and extensive margins of growth and allows for firms that face zero turnover or cash flow in a given month.[7] We also analyze a measure of total costs, which we compute based on total current account outflows for each SME in each month. We compute the same measure of year on year growth for this costs variable. Note that we are not able to separate out different components of inflows and outflows in the data.

For all of the SMEs in the data set we have registration numbers that allow us to match them to Companies House data acquired via Bureau van Dijk. This gives us additional information on their firm description, age, the sector in which they operate (their SIC code), simple balance sheet variables and the postcode of their headquarters.

2.2 Distances from local lockdowns and tier system

We use the postcodes in the SME current accounts data to work out where the businesses operate and how far they are from a given set of public health measures. These postcodes refer to the address each business uses for its banking services. We can validate these postcodes using the the address listed in Companies House, although those addresses are more likely to refer to headquarters or postal addresses rather than operating locations. Given the small size of the vast majority of businesses in the data set, this postcode is usually both the headquarters and the operating location of the business. There are around 1.7 million unique postcodes in the UK.[8] We use the postcode to estimate the exact operating location of each business based on the coordinates of the geographical midpoint of the area

[7] In practice, it means that all growth rates take values in the range -2 to +2. It is monotonically related to a conventional growth rate based on the formula $growth = \frac{2*DHS}{2-DHS}$.

[8] Note that multiple SMEs can share the same postcode and there are only around half the number of unique postcodes in our data set as there are unique SMEs.

to which each postcode refers.[9]

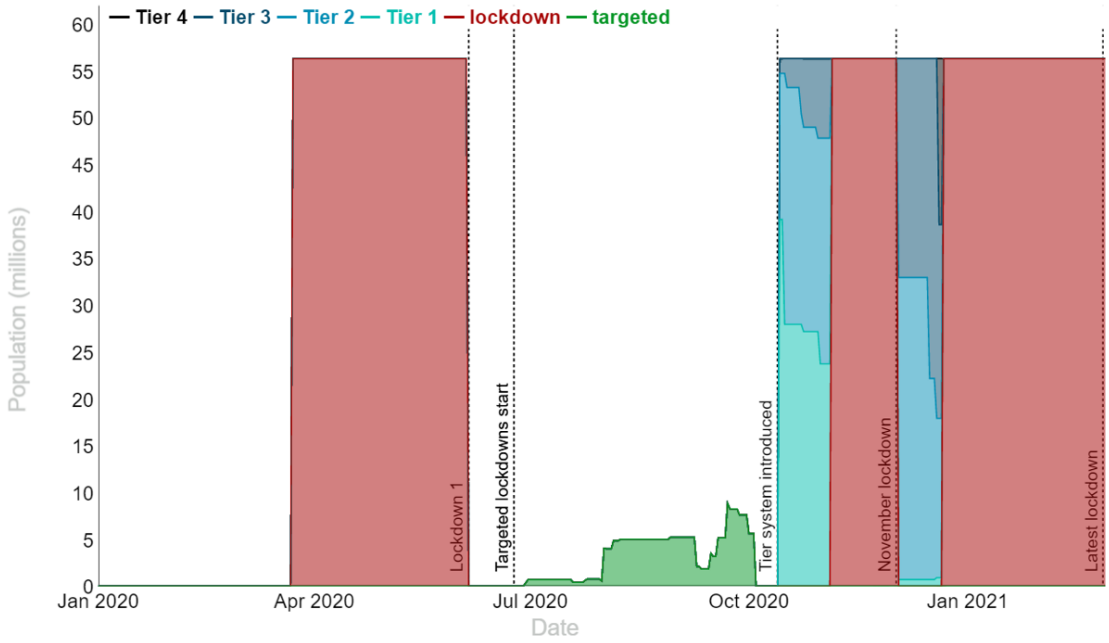

Figure 1: Public health measures in England since January 2020

All of the lockdown measures in England were applied at the local authority level. Figure 1 summarises the timing of the public health measures in England.[10] In this paper we analyse the local lockdowns that required businesses to close, which are shown in green on the chart, and the tier system, shown in blue. These measures came between the two national lockdowns in 2020 and in different months to one another.[11] Appendix B contains further details on how we identified the timing and location of the local lockdowns and tier system. To identify SMEs that were located close to the borders of the lockdowns, we use a shapefile for each of the local authorities which records the precise geographical location of the local authority borders.

Appendix C has more details on the spatial analysis. For each SME in each month

[9] To do this we used the postcodes.io API.

[10] Note that our analysis does include local lockdowns in Scotland and Wales, although they were not part of the tier system.

[11] We do not analyse the national lockdowns in this paper because the lack of spatial variation within the country means that we lack a meaningful control group and so cannot identify the causal impact of the lockdowns on activity.

we compute the minimum distance to the nearest set of public health measures that are different to the ones they are subject to. To do this we use the haversine distance, which is very accurate even at small distances. Figure 7 illustrates how this works in practice, where the red hexagons represent local authorities that are in a local lockdown and the green hexagons represent nearby local authorities that face looser measures. For a company at point A, we compute distance Y (note that X would be incorrect). In practice we produce the following calculations for all SMEs in each month that the **local lockdowns** were in place:

- For SMEs in the **local lockdown**, we compute one distance: the distance to the nearest local authority that is not under a local lockdown.
- For SMEs **not in the local lockdown**, we compute one distance: the distance to the nearest local authority that is under a local lockdown.

We produce the following calculations for all SMEs in each month that the **tier system** was in place:

- For SMEs in the **tier 1 restrictions**, we compute two distances: the distance to the nearest local authority that is under tier 2 and the distance to tier 3.
- For SMEs in the **tier 2 restrictions**, we compute two distances: the distance to the nearest local authority that is under tier 1 and the distance to tier 3.
- For SMEs in the **tier 3 restrictions**, we compute two distances: the distance to the nearest local authority that is under tier 1 and the distance to tier 2.

We use the resulting distance variables as the running variable in our regression discontinuity design. SMEs that are 'treated', meaning they are subject to stricter public health measures, have negative values of the distance variable. This negative distance denotes how far inside of the lockdown area the SME is located. For example, a company that is located 1 kilometre inside Leicester whilst the local lockdown was in place in the summer of 2020 has a distance value of -1 kilometre. As explained in the next section, we expect to see a jump in business activity around the border of the lockdowns i.e. around a value of 0 kilometres for the distance variable. Appendix B sets out further details on the spatial computations that we produce for the analysis in this paper.

2.3 Summary statistics

Table 1 records the number of observations in the data set we use to produce our main set of results. There are around 1.8 million UK SMEs in the data set. The local lockdowns lasted for up to three months: July, August and September 2020. This gives us around 4.1 million firm-month observations in total, 0.1 million of which are for SMEs that were inside the local lockdowns. The tier system was in place for two months: October and December 2020. Tier 2 affected almost twice as many SMEs as tier 1 and almost four times as many as tier 3.

Table 1: Number of observations by period

	Observations	Firms
Local lockdowns		
Outside	4,039,530	1,382,683
Inside	147,741	109,774
Tier system		
In tier 1	666,114	614,858
In tier 2	1,105,133	828,324
In tier 3	354,694	295,380

Table 2 presents some simple summary statistics for the local lockdown period. It splits the statistics on the basis of whether SMEs were subject to local lockdowns or not. The average SME saw around -20% turnover growth year on year both inside and outside of the local lockdowns over this period. Costs growth was similar inside and outside of the lockdowns too. The distribution of firm size - based on assets before the pandemic - and age was similar inside and outside of the lockdown.

Table 2: Summary statistics, local lockdown period

		Mean	10th %tile	25th %tile	Median	75th %tile	90th %tile
Turnover growth	Outside	-0.20	-2.00	-1.08	-0.10	0.50	1.56
	Inside	-0.19	-2.00	-1.04	-0.10	0.50	1.54
Costs growth	Outside	-0.14	-1.85	-0.84	-0.08	0.49	1.40
	Inside	-0.10	-1.84	-0.77	-0.05	0.55	1.50
Assets (£)	Outside	500,832	1,791	9,245	36,045	146,751	590,012
	Inside	348,990	1,700	8,646	34,505	142,164	532,695
Age (years)	Outside	8.38	2.19	3.55	6.22	10.41	16.65
	Inside	7.62	2.06	3.22	5.65	9.48	14.96

Table 3 contains summary statistics for the tier system period, split by the tier restrictions that SMEs were facing. Year on year turnover growth for the average SME ranged from -18% in tier 1 to -9% in tier 3. The distribution of firm characteristics was similar across the three tier levels.

Table 3: Summary statistics, tier system period

		Mean	10th %tile	25th %tile	Median	75th %tile	90th %tile
Turnover growth	In tier 1	-0.18	-2.00	-0.88	-0.09	0.44	1.39
	In tier 2	-0.14	-2.00	-0.97	-0.06	0.56	1.73
	In tier 3	-0.09	-2.00	-0.79	0.00	0.57	1.60
Costs growth	In tier 1	-0.15	-1.80	-0.77	-0.09	0.42	1.26
	In tier 2	-0.12	-1.87	-0.83	-0.07	0.52	1.52
	In tier 3	-0.08	-1.81	-0.71	-0.03	0.52	1.45
Assets (£)	In tier 1	409948	2303	10628	39120	151726	576972
	In tier 2	640,862	1,465	8,518	35,649	158,697	692,606
	In tier 3	371,374	1,789	8,750	35,424	154,618	608,540
Age (years)	In tier 1	8.80	2.11	3.60	6.52	11.05	17.59
	In tier 2	8.20	1.93	3.24	5.91	10.18	16.80
	In tier 3	8.10	1.79	3.05	5.72	10.15	16.98

Figure 6 in the appendix compares the SME turnover growth measure we use in our analysis with aggregate macroeconomic data obtained from the national accounts produced by the ONS. We have weighted the SME turnover growth measure by a lagged measure of firm size - based on their 2019 turnover - for consistency with the aggregate data. It shows that SME turnover growth has evolved broadly in line with gross operating surplus

for private non-financial companies, which in turn has tracked GDP growth over the past couple of years. All of the series troughed in the second quarter of 2020 and have recovered somewhat since then, although SME turnover growth has recovered least strongly.

3 Identification strategy

In this paper we are attempting to identify the causal impact of the Covid-19 lockdown measures on business activity. Table 2 in Hurley et al. [2021] presents the results from a naive regression of SME growth on a lockdown dummy, which would imply that the local lockdowns and tier system had very little impact on turnover or costs growth relative to periods from post-March 2020 onward when no restrictions were in place. However, this approach is subject to bias because it does not control for important differences between SMEs that were and were not subject to the restrictions, which could correlate with their growth. It also does not control for differences in the spread and fear of the virus in regions that were and were not subject to the restrictions.

We use a standard sharp regression discontinuity design [Hahn et al., 2001] to identify the impact of lockdown restrictions on business activity. More formally, we estimate versions of the following regression equation:

$$turnovergrowth_i = \beta_0 + \beta_1 lockdown_i + \beta_2 distance_i + \beta_3 lockdown_i * distance_i + \epsilon_i \quad (2)$$

$lockdown_{it}$ is a dummy variable that takes a value of 1 if an SME is subject to a given set of lockdown restrictions. $distance_i$ is the running variable in our analysis. It measures the distance of each SME from the nearest local lockdown or nearest different set of tier restrictions. We run the analysis within a given bandwidth, where $|distance_i| \leq bandwidth$, which we choose using the Calonico et al. [2014] bandwidth algorithm, which optimally trades off the bias and variance of the estimates.

The regression discontinuity design should identify the causal local average treatment effect of the lockdown restrictions on business activity. It relies on the assumption that the error term, ϵ_i, is continuous across the lockdown boundary. This is equivalent to assuming that SMEs that were located either side of lockdown boundaries — and their customers —

are no different to one another on all observable and unobservable characteristics and that there was no movement of SMEs across boundaries in response to the lockdowns (known as 'manipulation'). The local lockdowns are generally a good setting to carry out this analysis because they were unanticipated[12] and applied to businesses that could not move their operating address to get around them.

We can test these assumptions in the data to some extent. On manipulation, figure 8 shows that there is no discontinuous jump in the number of observations around the local lockdown boundaries, which is consistent with businesses not moving their operating locations in anticipation of the lockdown measures (they had a few weeks' notice at most). On characteristics, figure 9 confirms that firm size, proxied by total assets, displays no jump around the local lockdown boundaries. Figures 10 and 11 show that there are no discontinuities in leverage or sector shares around these boundaries either. However, figure 12 suggests that there is a small but significant jump in firm age at the boundaries of local lockdowns. Firms that are located just outside of local lockdowns tend to be slightly older than firms that are located just inside. We therefore control for firm age in all of the regressions we run to estimate the causal effect of local lockdowns.

4 Results

4.1 Impact of local lockdowns

Figure 13 visualizes how turnover growth varied at the boundaries of local lockdowns. It shows that SMEs that were just inside of the local lockdowns had lower turnover growth than those outside. The gray area is a 95% confidence interval and the blue line is a fitted fourth order polynomial. The discontinuity is most visible very close to the boundary (less than 2 kilometres). It is worth noting that turnover growth was around -20% over this period, whether or not firms were subject to the local lockdown restrictions. Those that were close to the local lockdowns had slightly higher average growth. Those that were subject to the local lockdowns had average growth of -19%. Figure 14 shows the same picture but for costs growth, where there is a smaller jump at the boundary.

[12] In fact, the mayors of some of the affected cities vocally complained in the media about a lack of warning and poor preparedness from central government, which made the announcements.

Table 4 contains the headline results we obtain from our regression discontinuity analysis, which provides formal estimates to back up the graphical analysis in figures 13 and 14. We find that the local lockdowns reduced SME turnover growth by around 8 percentage points on average and reduced costs growth by around 4 percentage points. The regressions use clustered standard errors and a firm age control variable. The optimal bandwidth picked by the Calonico et al. [2014] algorithm is around 2 kilometres in both regressions. The difference between the impacts on turnover and costs growth implies that the local lockdowns reduced SME cash flows.

Table 4: RDD estimates of the impact of the local lockdowns - headline results

	Dependent variable:	
	Turnover growth (year on year)	Costs growth (year on year)
	(1)	(2)
Local lockdowns	-0.079^{***}	-0.042^{***}
	(0.016)	(0.016)
Bandwidth (km)	2.1	1.85
Effective sample (in)	30048	25222
Effective sample (out)	31860	27472
Clustered standard errors	Yes	Yes
Firm age control	Yes	Yes

*p<0.1; **p<0.05; ***p<0.01

We have also mapped out how the impact of the local lockdowns varied over time. We produced these results by repeating the analysis and changing the dependent variable to a lead or a lag of the one we used in the main analysis, as opposed to a contemporaneous outcome. Figures 2 and 15 show that there is some evidence that the impact on turnover and costs growth was relatively short-lived and may have even reversed relatively soon after the local lockdowns ended. This could reflect factors like pent-up demand for goods and services sold by closed businesses after the local lockdowns were over.

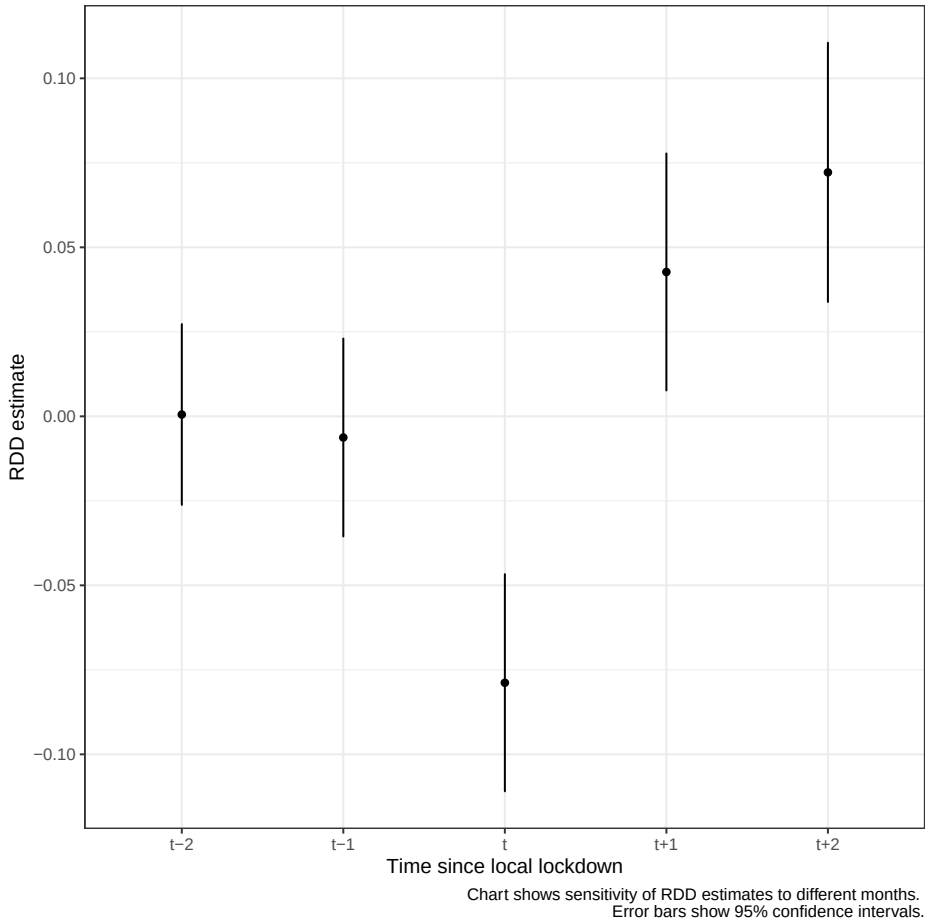

Figure 2: Impact of local lockdowns on SME turnover growth for different months

We have done some further analysis to assess how these estimated effects vary by different firm characteristics. Figure 3 shows the results from the same turnover growth regression as in table 4 repeated for samples containing only firms in certain sectors. The estimated effect of local lockdowns on turnover growth is statistically insignificant for most sectors. But firms in the *Accommodation and food* sector appear to have seen a large and statistically significant negative effect of local lockdowns on turnover growth, of around 12 percentage points. At the other end of the spectrum, there is no evidence that firms in the *Manufacturing* sector saw any reduction in turnover growth as a result of local lockdowns. Figure 16 repeats the analysis but for costs growth, showing similar effects as for turnover growth.

Figure 17 contains estimates for sub-sectors within *Accommodation and food* and shows

that there was a large and statistically significant reduction in turnover growth for *Licensed restaurants*, which were directly affected by the restrictions in most local lockdowns. Figure 18 contains estimates for sub-sectors in *Wholesale and retail*, showing that *Non-food retail* saw a large and statistically significant reduction in turnover growth. Figure 19 shows that the effect does not appear to vary by firm size. Figure 20 suggests that the local lockdown effect on turnover growth may have been larger for firms in the North West than the rest of the UK.

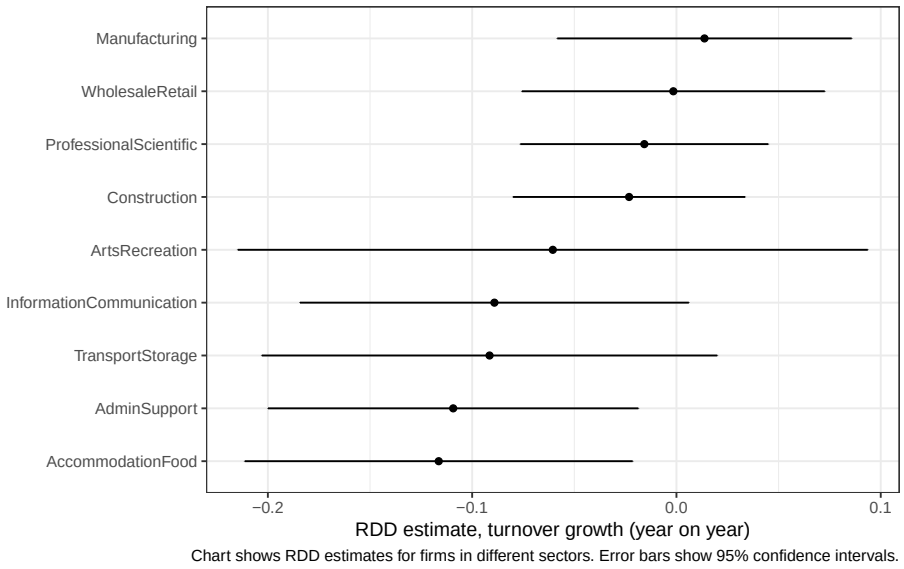

Figure 3: Impact of local lockdowns on SME turnover growth for different sectors

In the headline results we focus our analysis on local lockdowns that came with requirements for businesses to close. Appendix B has further details on how we defined the local lockdowns. Table 6 presents some alternative results for other forms of local lockdown, such as those in the north of England that focused on restricting certain forms of household mixing. These less strict local lockdowns do not appear to have a statistically significant effect on turnover growth, although there is evidence that they reduce cost growth by 3 percentage points.

4.2 Impact of tier system

In this section we extend the analysis to assess the impact of the tier system. Figure 21 shows how turnover growth varied at boundaries where the tier 2 restrictions met with tier 1. Compared to tier 1, tier 2 restrictions came with stricter requirements for hospitality businesses that meant alcohol could only be served with substantial meals, among other things. The chart shows that SMEs that were just inside tier 2 had around 10 percentage points lower turnover growth than those just inside tier 1. Figure 22 shows the same picture for costs growth, where there is a similar drop at the boundary. Table 5 presents the formal regression discontinuity estimates, which suggest that tier 2 led to a 6.5 percentage point drop in SME turnover growth and a 4 percentage point drop in costs growth compared to tier 1. Figure 23 plots different estimates for each sector, which provides some evidence that *Arts and recreation* businesses were hardest hit by these restrictions.

Table 5: RDD estimates of the impact of Tier 2 vs Tier 1 restrictions - headline results

	Dependent variable:	
	Turnover growth (year on year)	Costs growth (year on year)
	(1)	(2)
Tier 2 | Tier 1	-0.065^{***}	-0.042^{***}
	(0.014)	(0.015)
Bandwidth (km)	1.9	1.69
Effective sample (in)	46715	39900
Effective sample (out)	34724	30531
Clustered standard errors	Yes	Yes
Firm age control	Yes	Yes

*p<0.1; **p<0.05; ***p<0.01

The results for boundaries between tier 3 and tier 2 restrictions are less conclusive. Figure 24 shows how turnover growth varied at boundaries where the tier 3 restrictions met with tier 2. Tier 3 restrictions had even stricter requirements for hospitality businesses than tier 2, with their activity limited to takeaway meals. But the chart suggests there was no significant difference in turnover growth at the boundaries and this is confirmed more formally by table 7.

5 Robustness checks

In this section we briefly summarise the robustness checks we have conducted to increase confidence in our headline results. The detailed results of these checks are contained in Appendix A.

Table 8 shows that the headline results for the impact of local lockdowns on turnover growth do not depend on the choice of standard errors, polynomial specification or control variables. Our estimate of the causal effect of local lockdowns on turnover growth is around 8 percentage points under all of the alternative specifications.

We conduct placebo regression discontinuity analysis to check whether the results we find are spurious. In figure 25 we reproduce the headline results with different choices of cut-off - i.e. by picking placebo lockdown borders - and show that this renders the results statistically insignificant.

In our headline results we use the Calonico et al. [2014] bandwidth algorithm to choose the optimal bandwidth for the regression discontinuity estimates. In figure 4 we experiment with different choices of bandwidth to test how sensitive the results are to the outputs of this algorithm. We find that apart from in very narrow ranges around the boundaries, where we lose statistical power because of a small sample size, the headline results are relatively invariant to the choice of bandwidth.

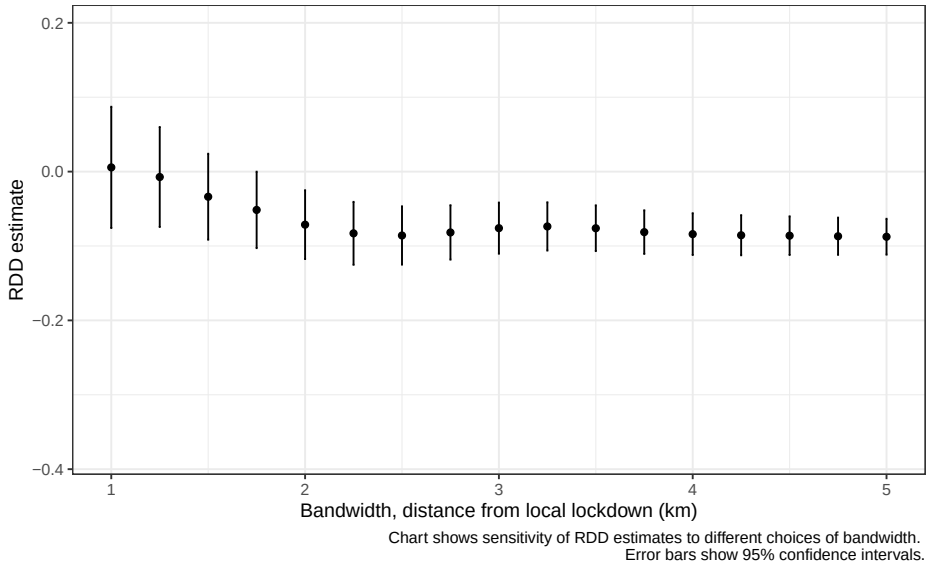

Figure 4: Impact of local lockdowns on SME turnover growth for different bandwidths

6 Discussion of the results

The previous section documented significant negative impacts on SME turnover and costs around local lockdown and tier system boundaries. Subject to the identifying assumptions set out earlier, this implies that the public health restrictions causally reduced SME business activity in the UK. Figure 5 puts the 8 percentage point reduction in turnover growth into context, showing that there was a 20% average year on year drop in turnover at that time for SMEs more generally. Most of this would probably have occurred even in the absence of the policies, because of factors like voluntary social distancing, although some might be a spillover from the measures. The drop in activity that was caused by the local lockdowns could be viewed as part of the social costs of the restrictions, whilst the most important social benefit probably came via reduction of the spread of the virus.[13]

[13]We are unable to do a full cost benefit analysis of the policies in this paper because we do not have the data or a good identification strategy to analyse the full range of policy benefits, many of which are epidemiological in nature.

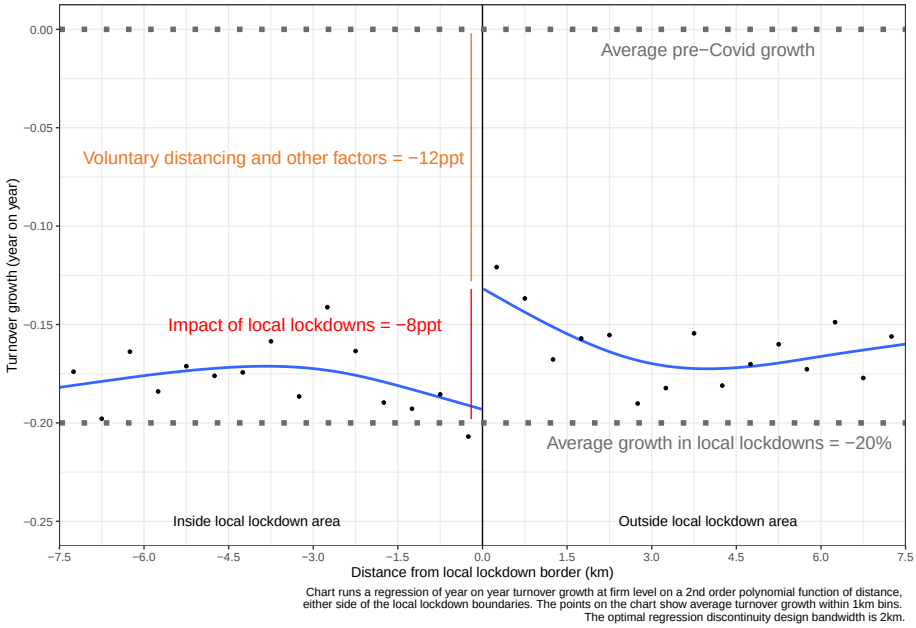

Figure 5: Impact of local lockdowns on SME turnover growth with indicative split by driver

Note that our method is not able to distinguish between negative impacts on businesses that are subject to the lockdowns and positive impacts on businesses that are just outside the lockdowns. It is possible that people responded to the measures by spending more money at nearby businesses that were just outside the lockdowns, boosting their turnover relative to a counterfactual where the measures were in place. Note that we are unable to quantify the scale of this spillover effect and that it would not exist in a national lockdown. But this makes the 8 percentage point reduction in turnover growth an upper bound on the impact on total business activity that was caused by local lockdowns. Figure 5 suggests that the measures accounted for two fifths of the impact on total business activity *at most*.

Even so, figure 4 provides some evidence that the effect size does not get smaller if we include more businesses that were further from the lockdown boundaries, and therefore presumably less likely to benefit from a spillover effect, although this also likely introduces some bias into the estimates. Table 9 also shows a set of results for *Licensed restaurants*, which were most likely to benefit from spillover effects. The second and third columns include dummy variables that control for the exact local lockdown borders businesses were on, and the regions they were in, which helps to focus in on spillover effects by identifying businesses

that were close together. The estimated effects do not get materially larger when we do this.

There are some important caveats that are worth bearing in mind when thinking through the policy implications of these findings. First, a large body of literature documents that the lockdown measures successfully reduced the spread of the virus in the UK and elsewhere. In the absence of the lockdown measures it is likely that there would have been more Covid-19 cases, hospitalizations and deaths. Second, the lockdown measures were implemented with view to stopping certain forms of economic activity that would risk increasing the spread of the virus. This includes eating in restaurants, drinking in bars and shopping for non-essentials. Our results show that the measures were effective in doing this. Third, even if the lockdown measures causally reduced business activity in a partial sense, this does not mean that removing them would not have led to an overall reduction in business activity caused by greater spread of the virus, more fear among the public and ultimately less consumer spending. We are unable to take into account general equilibrium effects like these in our analysis. Fourth, business activity was very low across the UK at the time of the local lockdowns, with average turnover growth of -20% year on year. In comparison to this, the direct effect of the local lockdowns on business activity was relatively small, even in the small geographical areas where they were in effect (-8 percentage points for the average SME). Fifth, there is some evidence that the impacts on business activity were relatively short-lived and may have reversed relatively quickly, as shown in figure 2.

This means that our results should not be taken as evidence against the success of the government's lockdown policies in general. But we hope the findings are useful in informing future public policy in relation to pandemics.

7 Conclusion

This paper estimates the causal effect of Covid-19 lockdown measures in the UK on SME business activity using a regression discontinuity design and novel data on SME current account flows. Focusing on lockdown measures that were applied at the sub-national level, it shows that there were significant drops in SME turnover and costs growth around the boundaries of the lockdown measures. But average turnover growth was very negative for SMEs throughout 2020 even when there were no specific public health measures in place, which suggests that business activity would have been likely to fall substantially even in the

absence of the measures.

The local lockdowns that were implemented in cities like Leicester and Manchester in the summer of 2020 led to around an 8 percentage point reduction in turnover growth for the average SME. This compares to average growth of -20% for all SMEs, whether or not they were subject to the local lockdowns, over the same period. The local lockdowns also reduced costs growth by around 4 percentage points. This reduction in growth appears to have been driven by businesses most directly affected by the measures, such as restaurants and non-food retail. Results for the tier system, which applied to the whole of England in October and December 2020, are more mixed. Tier 2 led to around a 6.5 percentage point drop in turnover growth relative to tier 1 but tier 3 had no statistically significant impact relative to tier 2.

The headline results are robust to a number of standard checks, including placebo analysis. On interpretation, it is important to note that the estimated impacts could reflect a combination of negative impacts on businesses that were subject to the local lockdowns and positive spillover effects on businesses that were not subject to the local lockdowns. This limits the direct read across to national lockdowns.

The results in this paper should be useful as governments and public health authorities consider the costs and benefits of policy responses to viral outbreaks in the future. They should not be read as evidence against lockdown policies, which were effective in reducing the spread of the virus.

Appendices

A Additional charts and tables

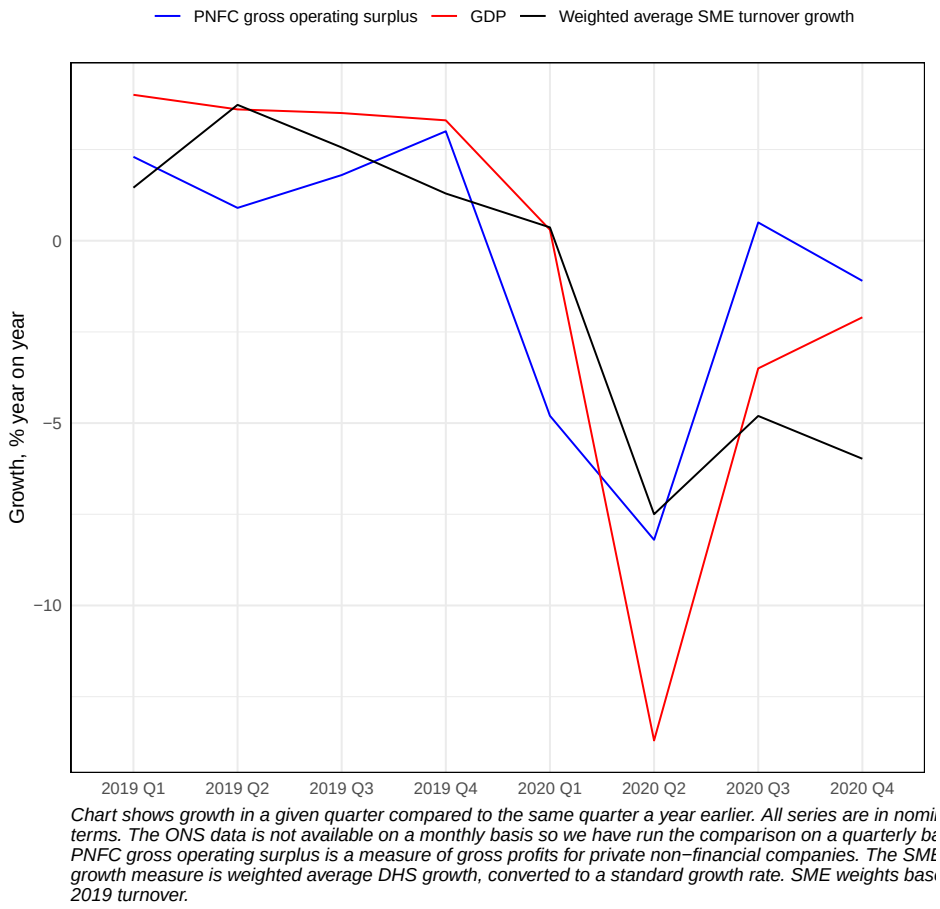

Figure 6: Comparison of SME turnover growth with aggregate data

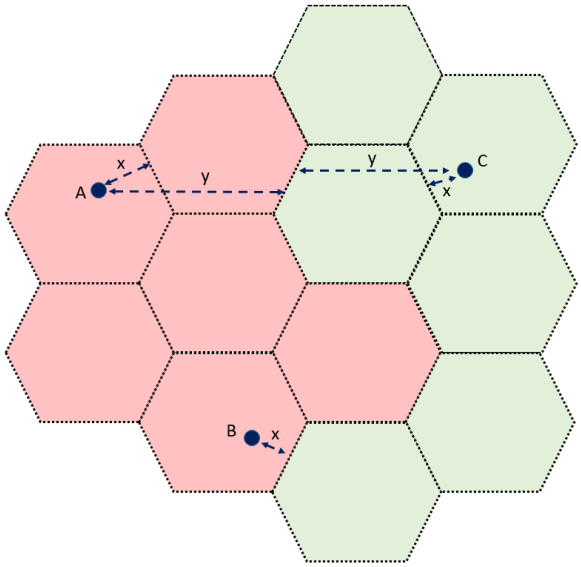

Figure 7: Illustrative example: computing the distance from nearest set of different public health measures

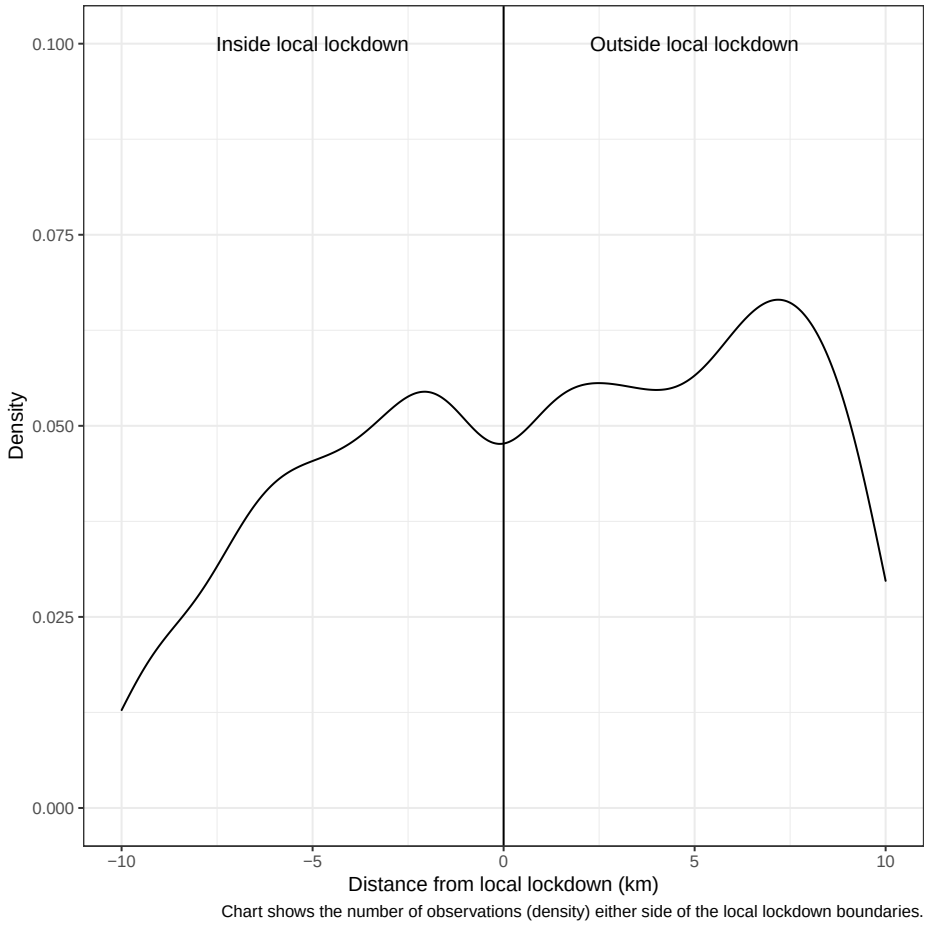

Figure 8: Density around local lockdown boundaries

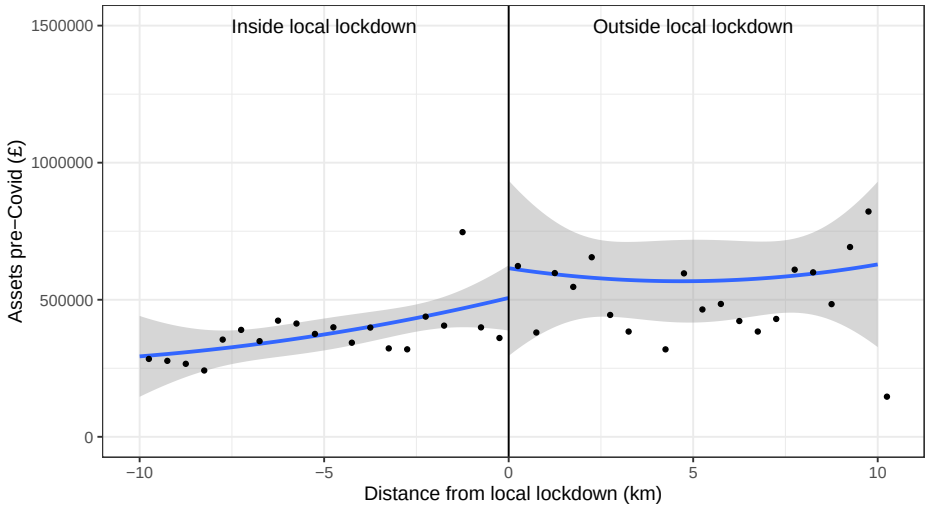

Chart runs a regression of assets in most recent period before Covid at firm level on a 2nd order polynomial function of distance, either side of the local lockdown boundaries. The points on the chart show average turnover growth within 1km bins. Shaded area is a 95% confidence interval.

Figure 9: Firm size (assets) at local lockdown boundaries

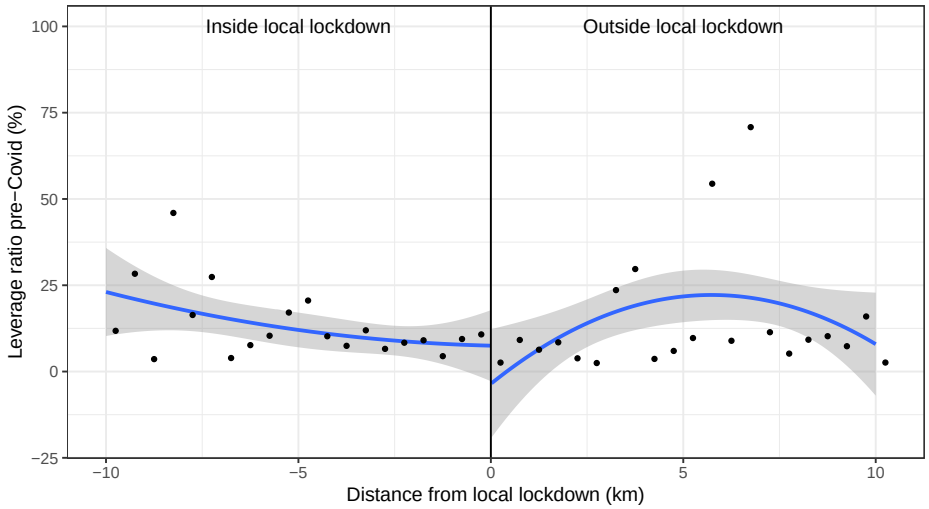

Chart runs a regression of leverage in most recent period before Covid at firm level on a 2nd order polynomial function of distance, either side of the local lockdown boundaries. The points on the chart show average turnover growth within 1km bins. Shaded area is a 95% confidence interval.

Figure 10: Leverage at local lockdown boundaries

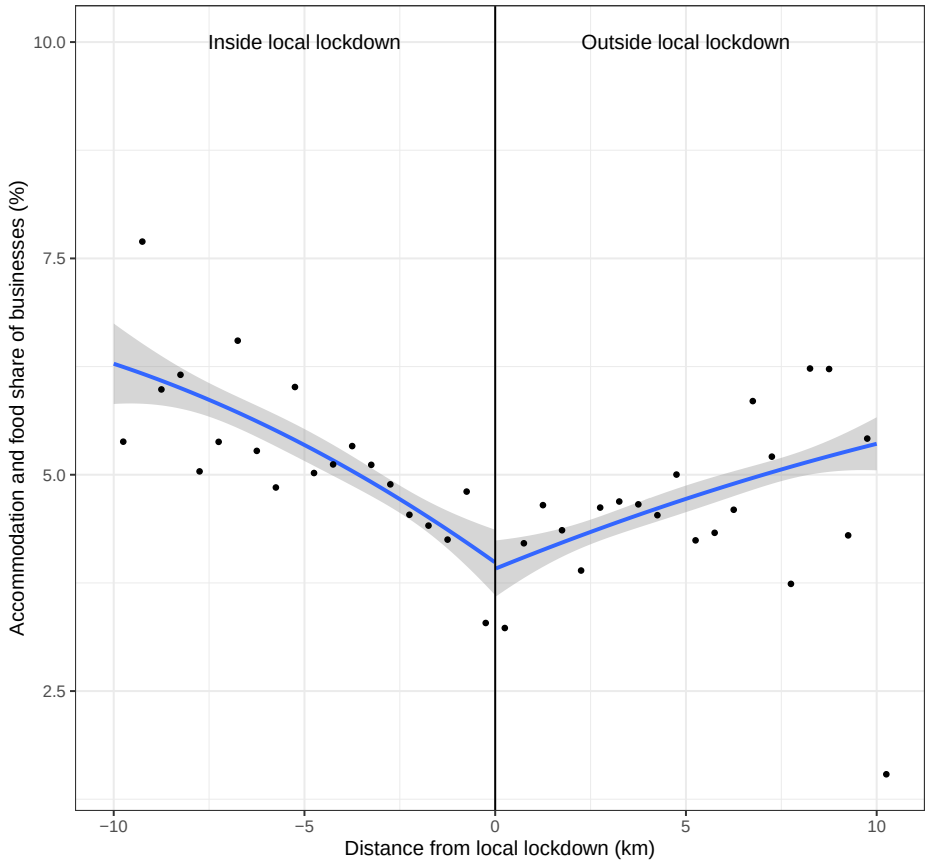

Chart runs a regression of an 'Accommodation and food' dummy at firm level on a 2nd order polynomial function of distance, either side of the local lockdown boundaries. The points on the chart show average turnover growth within 1km bins. Shaded area is a 95% confidence interval.

Figure 11: Retail sector share at local lockdown boundaries

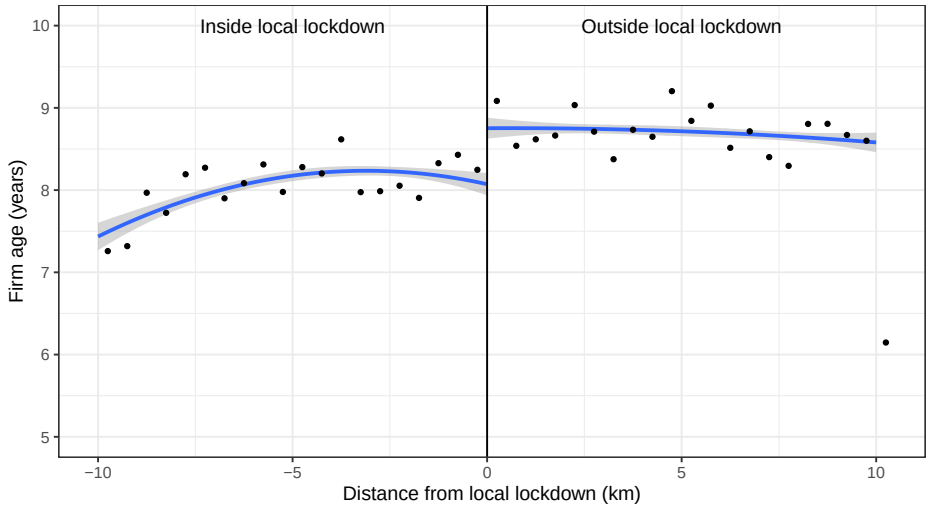

Figure 12: Firm age at local lockdown boundaries

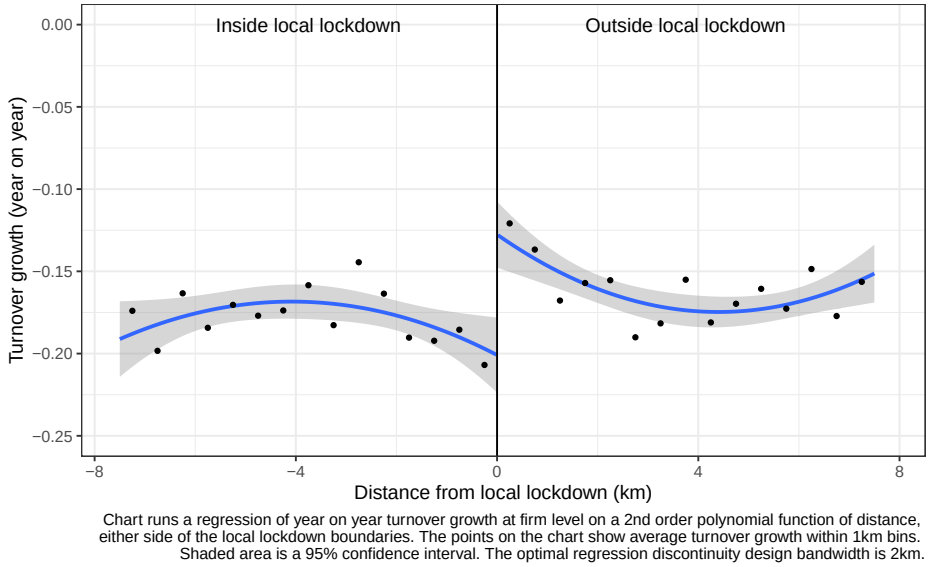

Figure 13: Impact of local lockdowns on SME turnover growth at the boundary

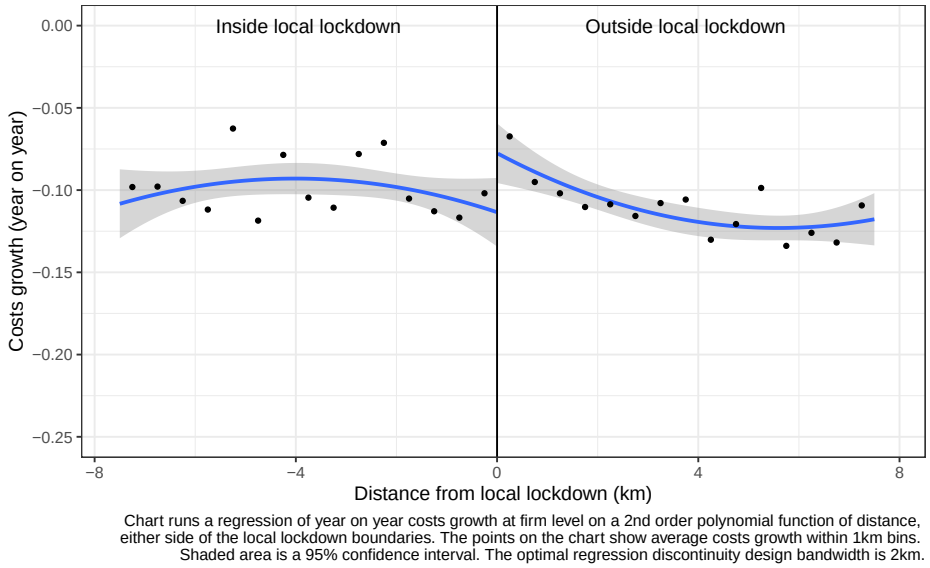

Figure 14: Impact of local lockdowns on SME costs growth at the boundary

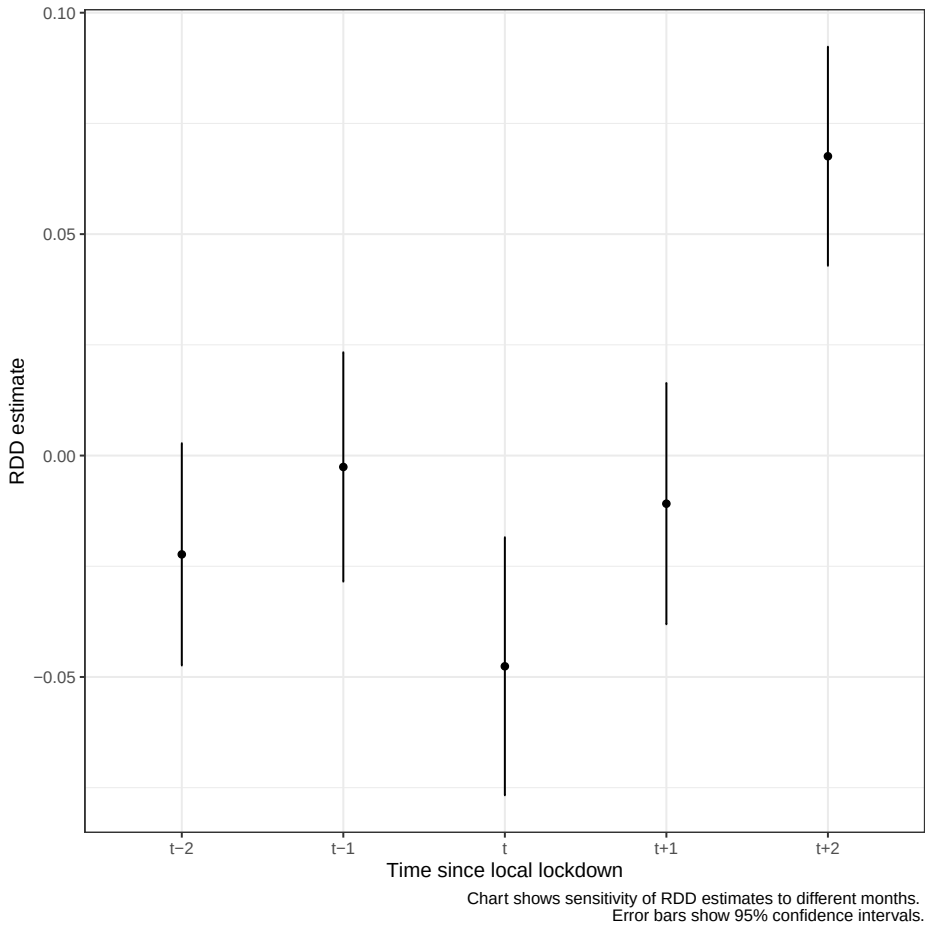

Figure 15: Impact of local lockdowns on SME costs growth for different months

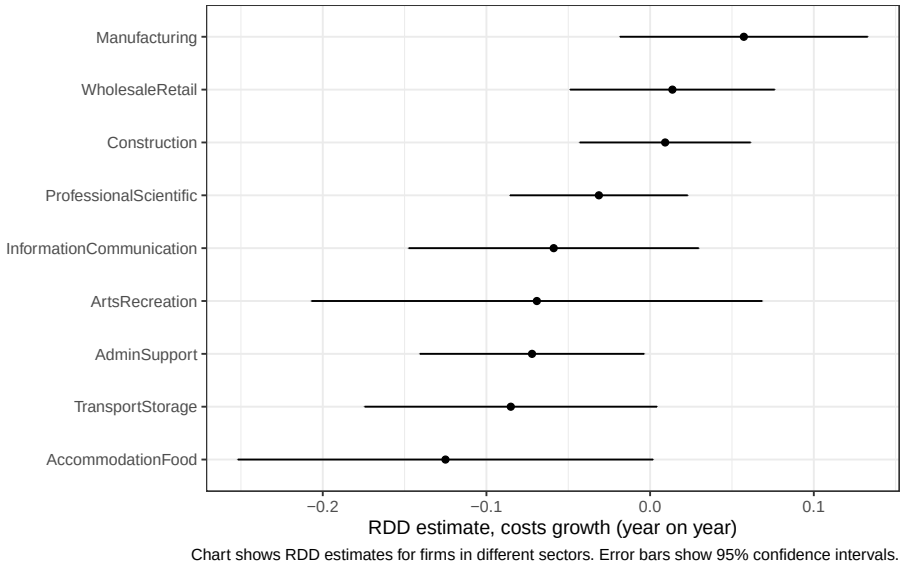

Figure 16: Impact of local lockdowns on SME costs growth for different sectors

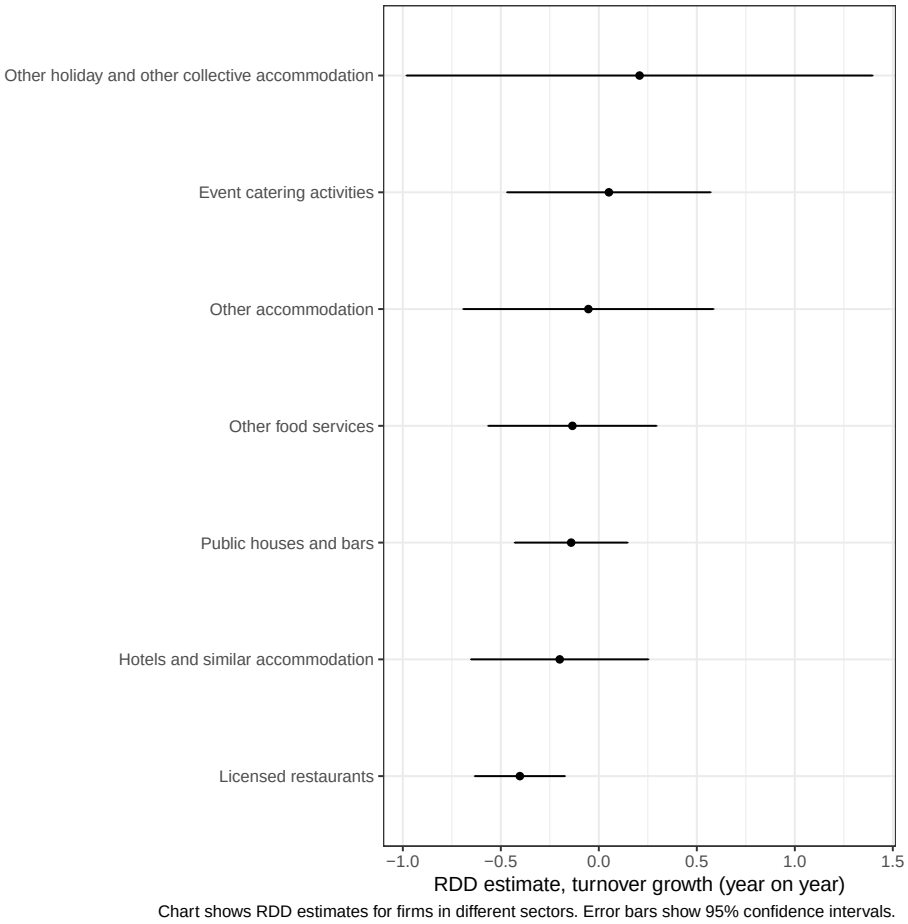

Figure 17: Impact of local lockdowns on SME turnover growth for different sub-sectors in Accommodation and food

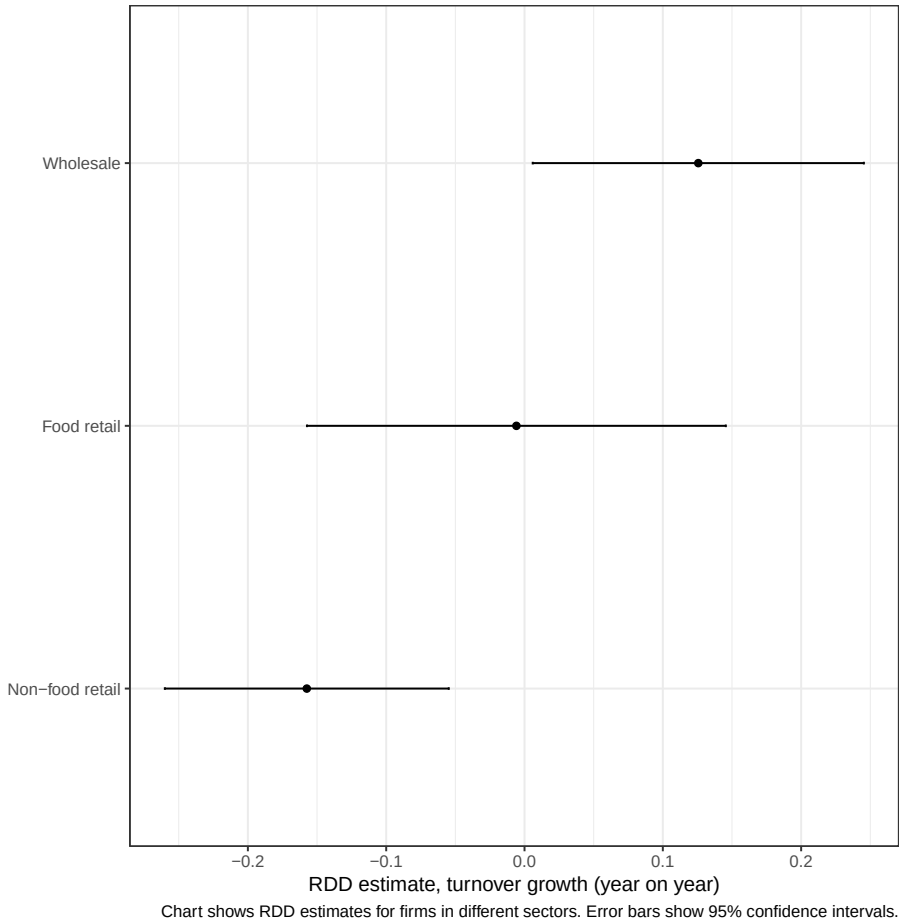

Figure 18: Impact of local lockdowns on SME turnover growth for different sub-sectors in Wholesale and retail

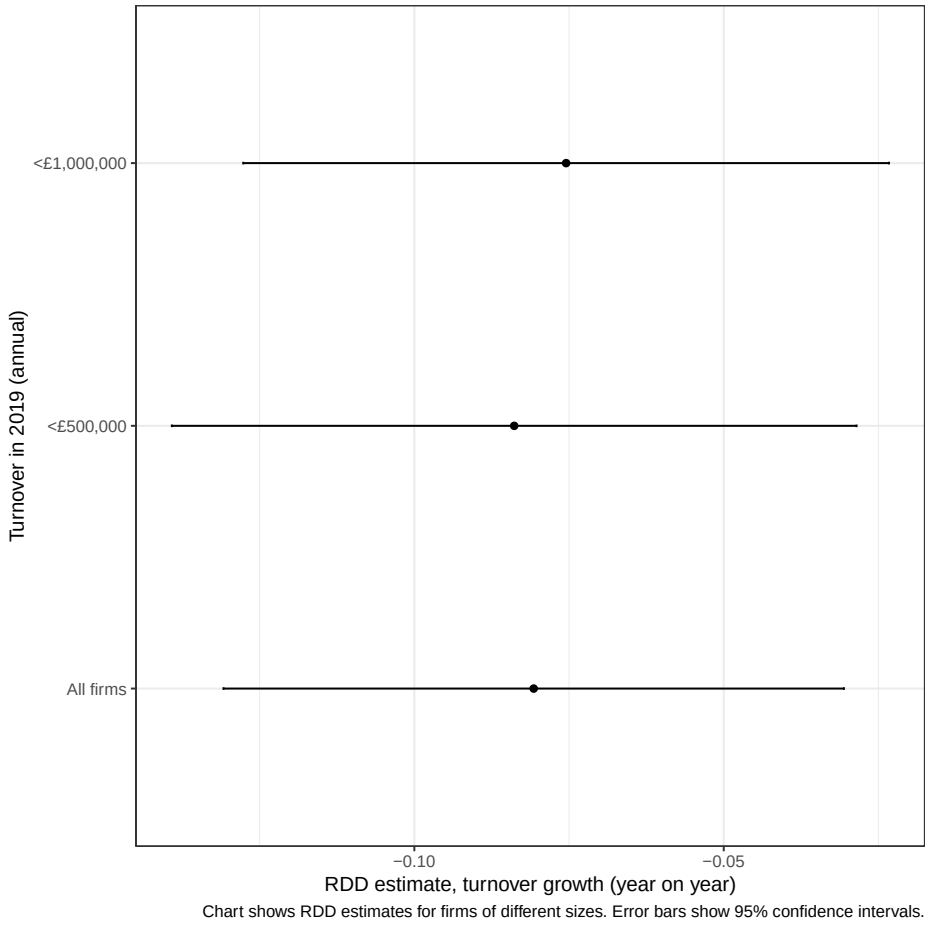

Figure 19: Impact of local lockdowns on SME turnover growth for different firm sizes

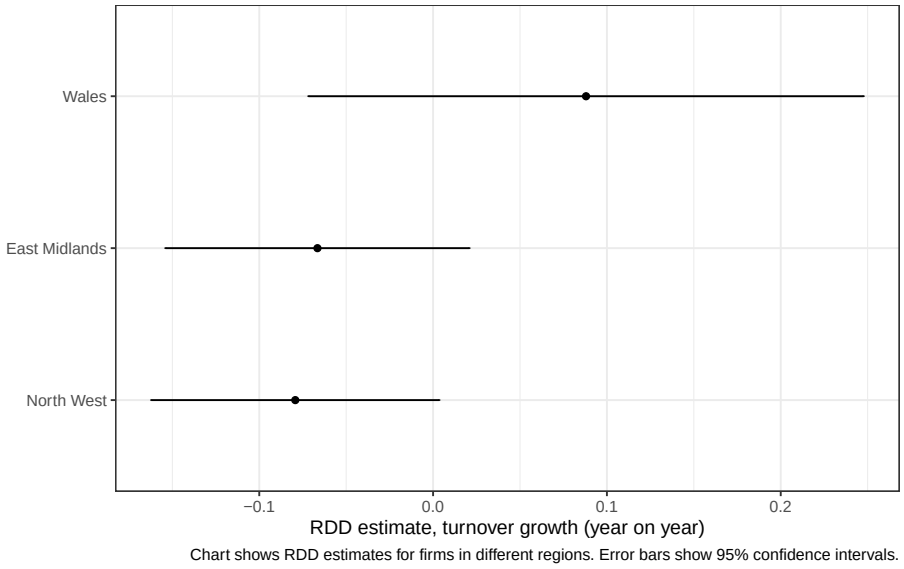

Figure 20: Impact of local lockdowns on SME turnover growth for different regions of the UK

Table 6: RDD estimates of the impact of the local lockdowns - less strict lockdowns

	Dependent variable:	
	Turnover growth (year on year)	Costs growth (year on year)
	(1)	(2)
Local lockdowns	0.012	−0.029**
	(0.012)	(0.011)
Bandwidth (km)	3.26	2.69
Effective sample (in)	41652	34645
Effective sample (out)	49814	40878
Clustered standard errors	Yes	Yes
Firm age control	Yes	Yes

*p<0.1; **p<0.05; ***p<0.01

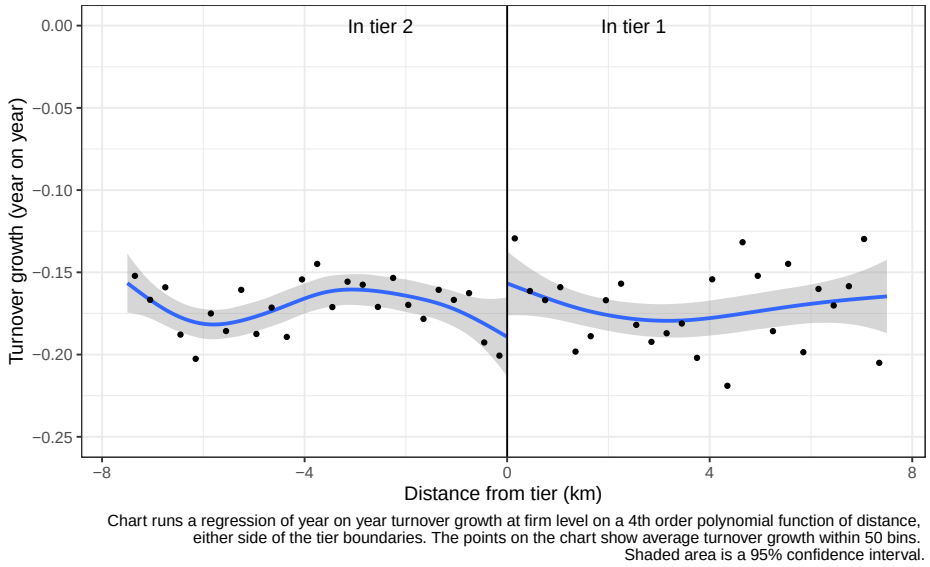

Figure 21: Impact of tier 2 restrictions on SME turnover growth at the boundary with tier 1

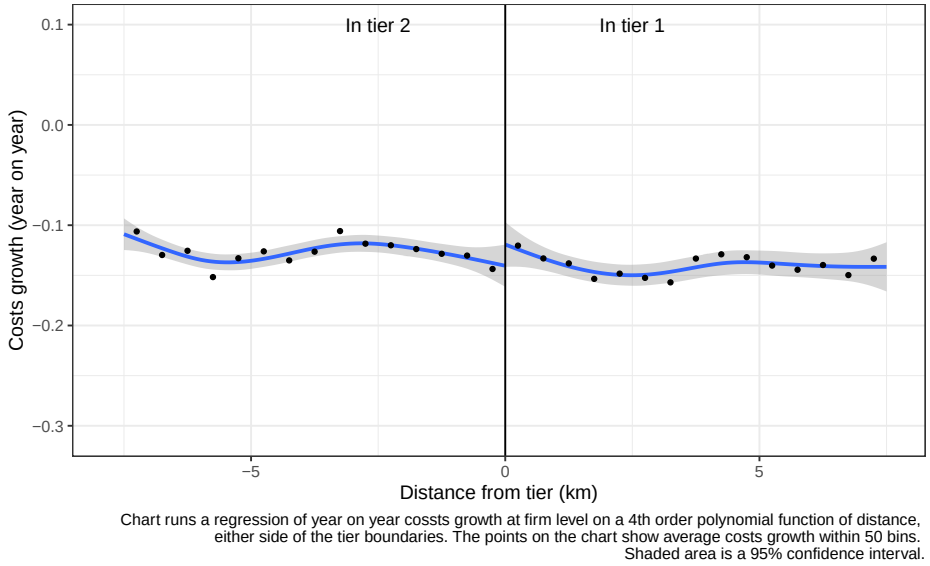

Figure 22: Impact of tier 2 restrictions on SME costs growth at the boundary with tier 1

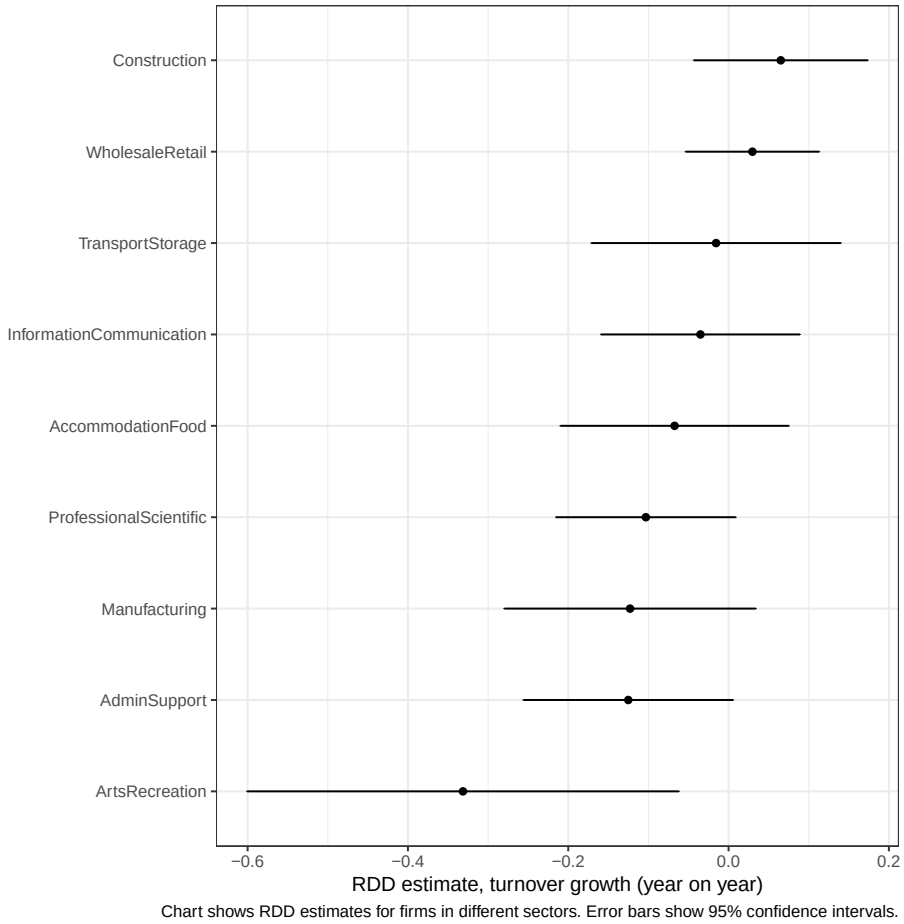

Figure 23: Impact of tier 2 restrictions on SME turnover growth at the boundary with tier 1 for different sectors

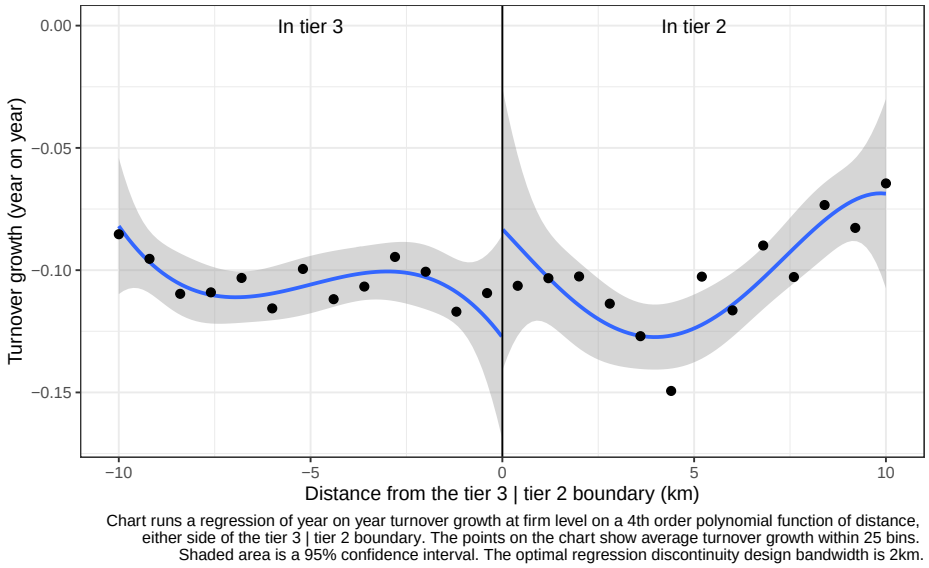

Figure 24: Impact of tier 3 restrictions on SME turnover growth at the boundary with tier 2

Table 7: RDD estimates of the impact of Tier 3 vs Tier 2 restrictions - headline results

	Dependent variable:	
	Turnover growth (year on year)	Costs growth (year on year)
	(1)	(2)
Tier 3 | Tier 2	−0.031	−0.033*
	(0.026)	(0.019)
Bandwidth (km)	2.78	3.74
Effective sample (in)	32496	43470
Effective sample (out)	17108	23927
Clustered standard errors	Yes	Yes
Firm age control	Yes	Yes

*p<0.1; **p<0.05; ***p<0.01

Table 8: RDD estimates of the impact of the local lockdowns - alternative specifications

	Dependent variable:			
	Turnover growth (year on year)			
	(1)	(2)	(3)	(4)
Local lockdowns	-0.080^{***}	-0.079^{**}	-0.079^{***}	-0.076^{***}
	(0.025)	(0.032)	(0.016)	(0.021)
Bandwidth (km)	2.33	2.49	2.1	2.81
Effective sample (in)	33788	36302	30048	41176
Effective sample (out)	35701	38156	31860	43050
Clustered standard errors	No	Yes	Yes	Yes
Firm age control	No	No	Yes	Yes
Polynomial order	1	1	1	2

*p<0.1; **p<0.05; ***p<0.01

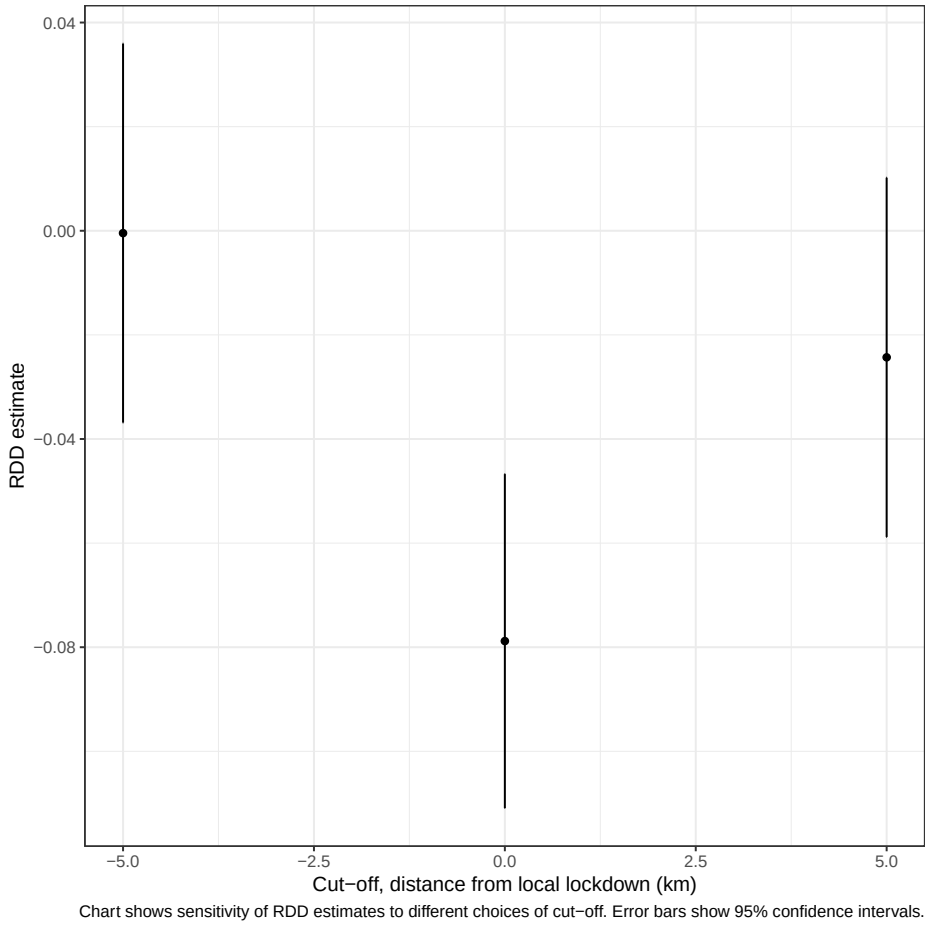

Figure 25: Impact of local lockdowns on SME turnover growth for different cut-offs

Table 9: RDD estimates of the impact of the local lockdowns with border and region dummies - Licensed Restaurants

	Dependent variable:		
	Turnover growth (year on year)		
	Normal	Region Dummy	Border Dummy
	(1)	(2)	(3)
Lo callo ckdowns	-0.396^{**}	-0.350^{*}	-0.417^{**}
	(0.172)	(0.179)	(0.195)
Bandwidth (km)	3	3	3
Note:			*p<0.1; **p<0.05; ***p<0.01

B Defining local lockdowns and tiers

We extracted local lockdown and tier system information from government or local authority websites. We summarised these at a monthly frequency based on whether or not the majority of days in a given month were spent in the local lockdown or a given set of tier restrictions. We focused the final analysis on local lockdowns that we denote as "Strong" in the table below, meaning they came with requirements for certain businesses to close. The results of this process are also recorded in figure 1.

Table 10: List of local lockdowns and their key features

Local Authority District	Region	Month	Restrictions	Type
Birmingham	West Midlands	Sept	No indoor mixing	Weak
Sandwell	West Midlands	Sept	No indoor mixing	Weak
Solihull	West Midlands	Sept	No indoor mixing	Weak
Blaby	East Midlands	July	Non-essential retail, restaurants, school and gyms closed	Strong
Charnwood	East Midlands	July	Non-essential retail, restaurants, school and gyms closed	Strong
Blackburn with Darwen	North West	Aug - Sept	Non-essential retail, restaurants, school and gyms closed	Strong
Oadby and Wigston	East Midlands	July	Non-essential retail, restaurants, school and gyms closed	Strong
Leicester	East Midlands	July - Aug	Non-essential retail, restaurants, school and gyms closed	Strong
Manchester	North West	Aug - Sept	Non-essential retail, restaurants, school and gyms closed	Strong
Oldham	North West	Aug - Sept	Non-essential retail, restaurants, school and gyms closed	Strong
Bolton	North West	Aug - Sept	Non-essential retail, restaurants, school and gyms closed	Strong
Trafford	North West	Aug	Non-essential retail, restaurants, school and gyms closed	Strong
Stockport	North West	Aug	Non-essential retail, restaurants, school and gyms closed	Strong
Bury	North West	Aug	Non-essential retail, restaurants, school and gyms closed	Strong
Wigan	North West	Aug	Non-essential retail, restaurants, school and gyms closed	Strong
Tameside	North West	Aug	Non-essential retail, restaurants, school and gyms closed	Strong
Rochdale	North West	Aug	Non-essential retail, restaurants, school and gyms closed	Strong
Salford	North West	Aug	Non-essential retail, restaurants, school and gyms closed	Strong
Burnley	North West	Aug	Non-essential retail, restaurants, school and gyms closed	Strong
Hyndburn	North West	Aug	Non-essential retail, restaurants, school and gyms closed	Strong
Pendle	North West	Aug	Non-essential retail, restaurants, school and gyms closed	Strong
Rossendale	North West	Aug	Non-essential retail, restaurants, school and gyms closed	Strong
Preston	North West	Aug	Non-essential retail, restaurants, school and gyms closed	Strong
Bradford	Yorkshire and The Humber	Aug	Non-essential retail, restaurants, school and gyms closed	Strong
Kirklees	Yorkshire and The Humber	Aug	Non-essential retail, restaurants, school and gyms closed	Strong
Calderdale	Yorkshire and The Humber	Aug	Non-essential retail, restaurants, school and gyms closed	Strong
Glasgow City	Scotland	Sept	No indoor mixing	Weak
East Renfrewshire	Scotland	Sept	No indoor mixing	Weak
West Dunbartonshire	Scotland	Sept	No indoor mixing	Weak
Renfrewshire	Scotland	Sept	No indoor mixing	Weak
East Dunbartonshire	Scotland	Sept	No indoor mixing	Weak
South Lanarkshire	Scotland	Sept	No indoor mixing	Weak
North Lanarkshire	Scotland	Sept	No indoor mixing	Weak
Belfast	Northern Ireland	Sept	No indoor mixing	Weak
Caerphilly	Wales	Sept - Oct	Pubs, bars and restaurants to close early	Strong
Rhondda Cynon Taf	Wales	Sept - Oct	Pubs, bars and restaurants to close early	Strong
Blaenau Gwent	Wales	Oct	Pubs, bars and restaurants to close early	Strong
Bridgend	Wales	Oct	Pubs, bars and restaurants to close early	Strong
Merthyr Tydfil	Wales	Oct	Pubs, bars and restaurants to close early	Strong
Newport	Wales	Oct	Pubs, bars and restaurants to close early	Strong
Cardiff	Wales	Oct	Pubs, bars and restaurants to close early	Strong
Swansea	Wales	Oct	Pubs, bars and restaurants to close early	Strong
Neath Port Talbot	Wales	Oct	Pubs, bars and restaurants to close early	Strong
Torfaen	Wales	Oct	Pubs, bars and restaurants to close early	Strong
Vale of Glamorgan	Wales	Oct	Pubs, bars and restaurants to close early	Strong
Conwy	Wales	Oct	No indoor mixing	Weak
Denbighshire	Wales	Oct	No indoor mixing	Weak
Flintshire	Wales	Oct	No indoor mixing	Weak
Wrexham	Wales	Oct	No indoor mixing	Weak

C Estimating distance to lockdowns and tiers

The running variable in our RDD analysis is the distance of each company to the nearest set of different public health restrictions. This requires calculating minimum distances between company postcodes and local authority borders. Local authorities moved in and out of lockdowns or tiers over time, meaning that we needed to recalculate the distance for each company several times. This involved three main steps:

1. We converted each of the 1.2 million unique company postcodes in the data set into latitude and longitude coordinates using the postcodes.io API.

2. We collected a shapefile for each of the 312 local authorties from the ONS to obtain the boundary coordinates. We then calculated the minimum haversine distance for each company's postcode to every local authority district. The haversine distance was used as it takes into account the curvature of the earth and is very accurate at small distances. As every local authority district had around 300 coordinates for its boundary, this required calculating the minimum distance for all 1.2 million postcodes to 300 coordinates for all 312 local authority districts. This meant 182 billion individual calculations.

3. For each local authority in each month we created an indicator variable to record which set of public health restrictions they were subject to, as explained in the previous appendix.

4. We assigned each company a negative or positive distance to the nearest border of interest, based on whether or not they were in the treatment or the control group i.e. inside or outside the stricter set of public health restrictions.

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