

A Detailed Derivation of $\text{plim}(\hat{\beta})$

This appendix derives $\text{plim}(\hat{\beta})$ for the log specification used in the main text. For clarity, we abstract from fixed effects and controls and focus on the mechanics of attenuation.

Define $r \equiv \ln(R)$ and $r^* \equiv \ln(R^*)$, and $n \equiv \ln(N)$ and $n^* \equiv \ln(N^*)$. The log measurement system and structural relationship are

$$r = \ln(\lambda) + r^* + u_r, \quad n = \ln(\varphi) + n^* + u_n, \quad n^* = \alpha_0 + \gamma r^* + u.$$

Substituting yields

$$n = \underbrace{\ln(\varphi) + \alpha_0}_{\text{constant}} + \gamma r^* + u + u_n, \quad r = \underbrace{\ln(\lambda)}_{\text{constant}} + r^* + u_r.$$

Since OLS is invariant to additive constants, the wedges $\ln(\lambda)$ and $\ln(\varphi)$ and the constant α_0 affect the intercept but not the slope; we therefore demean r and n .

Let $\sigma_{r^*}^2 \equiv \text{Var}(r^*)$. Assume the latent components satisfy the orthogonality conditions

$$\text{Cov}(r^*, u) = \text{Cov}(r^*, u_n) = \text{Cov}(r^*, u_r) = 0, \quad \text{Cov}(u, u_n) = \text{Cov}(u, u_r) = \text{Cov}(u_n, u_r) = 0.$$

With constants removed,

$$n = \gamma r^* + u + u_n, \quad r = r^* + u_r.$$

A.1 Covariance $\text{Cov}(n, r)$

$$\text{Cov}(n, r) = \text{Cov}(\gamma r^* + u + u_n, r^* + u_r) = \gamma \text{Var}(r^*) = \gamma \sigma_{r^*}^2.$$

A.2 Variance $\text{Var}(n)$

$$\text{Var}(n) = \gamma^2 \sigma_{r^*}^2 + \sigma_u^2 + \sigma_{u_n}^2.$$

A.3 Putting It All Together

$$\text{plim}(\hat{\beta}) = \frac{\text{Cov}(n, r)}{\text{Var}(n)} = \frac{\gamma \sigma_{r^*}^2}{\gamma^2 \sigma_{r^*}^2 + \sigma_u^2 + \sigma_{u_n}^2} = \frac{1}{\gamma} \times \frac{1}{1 + \frac{\sigma_u^2}{\gamma^2 \sigma_{r^*}^2} + \frac{\sigma_{u_n}^2}{\gamma^2 \sigma_{r^*}^2}}.$$

Whenever $\sigma_u^2 > 0$ or $\sigma_{u_n}^2 > 0$, the fraction is strictly less than 1, so $\hat{\beta}$ is attenuated (biased toward zero) relative to $1/\gamma$.

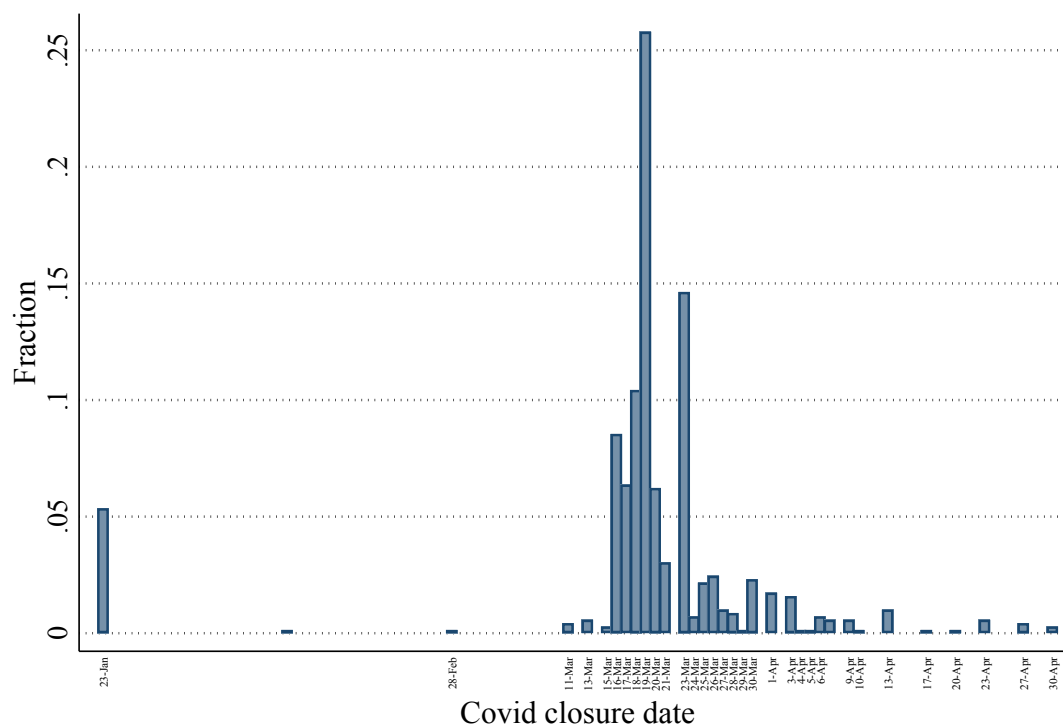
B Additional descriptive statistics

Figure B1: Factory day and nightlight images: example.



Note: This figure summarizes the tagging process. The first image is a daylight image from bing.com (© 2020 Microsoft). The second image shows how each factory is tagged, the last image is the nightlight produced by that factory that comes from VIIRS monthly average for 2014 in this example.

Figure B2: Distribution of Covid-19 closing dates.



Note: This figure plots the distribution of Covid-19 closing dates for 2020. The dataset was hand-collected using marklines.com portal followed by news updates provided by just-auto.com. We only collected information for the first Covid-19 related closure, not the subsequent supply-related closures.

Table B1: Descriptive statistics: subsidiary-level financial and lights data.

variable	mean	median	sd	min	max
Panel A: Panel Data					
$\ln(N_{it})$	5.86	6.02	1.86	-1.36	10.6
$\ln(N_{it}/area_i)$	5.75	5.82	0.71	1.61	7.49
$\ln(\text{light 5km ring})$	4.63	4.68	0.88	1.9	6.89
area	0.47	0.21	0.84	0	7.33
$\ln(\text{turnover})$	13.33	13.31	2.12	7.91	18.42
$\ln(\text{total assets})$	12.99	12.9	1.96	9.05	18.87
$\ln(\text{employment})$	7.28	7.24	2	0	12.11
$\ln(\text{fixed assets})$	12.02	11.89	2.35	6.54	18.73
$\ln(\text{profit and loss before tax})$	10.27	10.13	2.29	4.96	15.85
number of subsidiaries	555				
Panel B: Cross sectional Data					
$\ln(N_i)$	5.81	5.95	1.78	1.21	10.55
$\ln(N_i/area_i)$	5.79	5.84	0.64	3.38	7.36
$\ln(\text{light 5km ring})$	4.62	4.67	0.89	2.19	6.71
area	0.42	0.19	0.79	0	7.32
$\ln(\text{turnover})$	13.06	13.09	2.27	6.33	17.99
$\ln(\text{total assets})$	12.96	12.85	1.92	9.07	18.73
$\ln(\text{employment})$	6.97	6.91	1.86	0	11.28
$\ln(\text{fixed assets})$	11.95	11.88	2.4	5.83	18.43
$\ln(\text{profit and loss before tax})$	10.03	10.03	2.17	4.93	15.62
number of subsidiaries	555				

Note: This table provides summary statistics related to firm-level data. In Panel A, we show nightlight and financial data summary for the panel data sample and in panel B, we show data summary for the cross-sectional data sample. $\ln(N_i)$ is the logarithm of the total light emitted by a factory. $\ln(N_i/area_i)$ is the logarithm of the light emitted by a factory divided by the factory area. $\ln(\text{light 5km ring})$ measures the mean light within a 5 km radius around the factory, excluding the factory itself. The nightlight-related variables come from VIIRS dataset. The area is a factory area in square kilometers, measured by the footprint of the factory buildings. Financial data related to turnover, total assets, employment, fixed assets and profit and loss before taxes comes from Orbis. All the financial variables are reported at the unconsolidated subsidiary level. The number of subsidiaries indicates the number of firms for which we observe nightlight data in this sample. Turnover, assets and profits are missing for some of those observations.

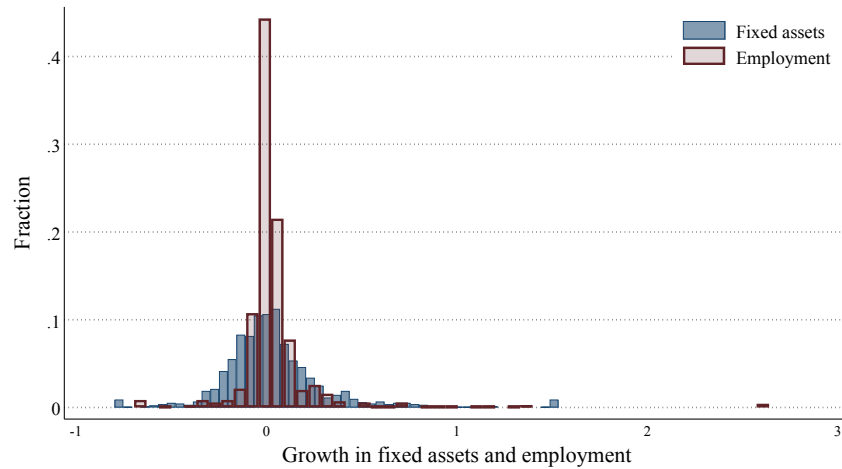
Table B2: Subsidiary-level financial variables: cross-correlations.

	ln(turnover)	ln(assets)	ln(employment)	ln(fixed assets)	log(profit)
Panel A: Cross-sectional Data					
ln(turnover)	1				
ln(assets)	0.8841*	1			
ln(employment)	0.8466*	0.8058*	1		
ln(fixes assests)	0.7988*	0.9352*	0.7547*	1	
ln(profit)	0.8787*	0.8735*	0.7989*	0.8370*	1
Panel B: Panel Data					
ln(turnover)	1				
ln(assets)	0.9119*	1			
ln(employment)	0.8423*	0.8222*	1		
ln(fixes assests)	0.8373*	0.9486*	0.8118*	1	
ln(profit)	0.8693*	0.8617*	0.7730*	0.8142*	1

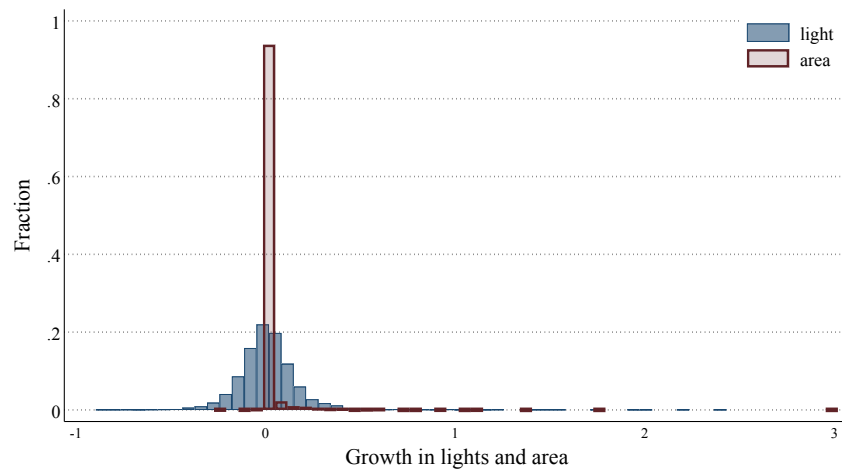
Note: This table provides correlation coefficients between financial variables. * indicates that a correlation is significant at 1% level. Panel A provides correlations for the cross-sectional sample, Panel B for panel-level sample.

Figure B3: Distribution of growth rates in subsidiary area, nightlight and operations across years.

(a) Employment and fixed assets.



(b) Nightlight and area.

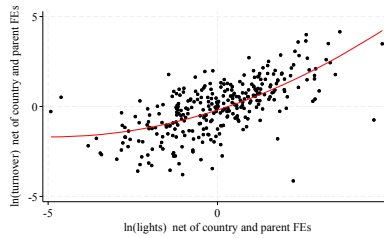


Note: The figure presents the distribution of annual growth rates in firm operations, nightlight and area during the analyzed sample period. In Panel (a), we show changes in employment and fixed assets, while in Panel (b), we show changes in night and area.

Figure B4: The correlations between firm activities and nightlights.

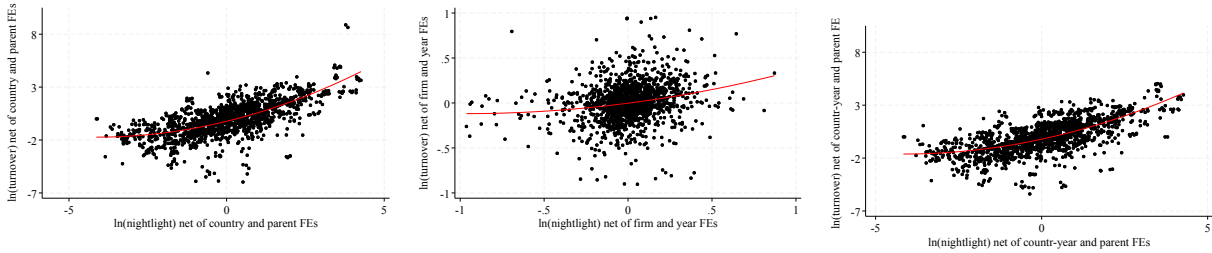
Cross-section

(a) Cty, parent FEs residualized.



Panel

(b) Cty, parent FEs residualized (c) Firm, year FEs residualized (d) Cty x year, parent FEs residualized



Note: This figure presents the relationship between turnover and nightlights, both net of different fixed effects. Each dot corresponds to a single subsidiary. All variables are in logs. In all panels, we include logarithm of turnover net of different fixed effects (as labeled in the figure title and on the axis) on the vertical axis. On the horizontal axis, we include logarithm of total nightlight net of different fixed effects. In panels (a) and (b), we net out country and parent FEs, in panel (c) we net out firm and year FEs and in panel (d), we net out parent and time-varying country FEs. In Panel (a), we use cross sectional data, in Panels (c)-(d) we use panel data. The red line is a regression line between the two residualized variables using the fractional polynomial fit of degree 1.

C Outliers analysis

Table C1: The distribution of subsidiaries in the top decile of the prediction error: parent firms.

	top decile of error	deciles 4-7
Mitsubishi	66.67	33.33
Subaru	66.67	33.33
Ford	58.33	41.67
Mazda	50	50
BMW	37.5	62.5
GM	33.33	66.67
Geely	25	75
Honda	20	80
Renault	20	80
vw	17.39	82.61
Mercedes	16.67	83.33
Volvo	11.11	88.89
FCA	7.69	92.31
PSA	7.41	92.59
Toyota	5.56	94.44
Hyundai	0	100
Suzuki	0	100
Kia	0	100
Tesla	0	100

Note: This table summarizes the distribution of subsidiaries for which we make a large prediction error using the nightlight data relative to their reported economic activity. We use predictions based on Panel a of Figure 1. In each column we show the share of subsidiaries that belong to each car manufacturer for which we make a large error and a share for which we do not. Top decile error indicates subsidiaries in the top 10th percentile of the distribution of the prediction error, deciles 4-7 indicates all those subsidiaries for which the error is relatively close to zero.

Table C2: The distribution of firms in the top decile of the prediction error: countries.

	top decile of error	deciles 4-7
Argentina	100	0
Canada	100	0
Mexico	100	0
Uruguay	100	0
Venezuela	100	0
United States	90	10
Russia	50	50
Egypt	50	50
Japan	50	50
Netherlands	50	50
Vietnam	50	50
Brazil	45.45	54.55
Malaysia	33.33	66.67
Thailand	27.27	72.73
Philippines	25	75
Spain	14.29	85.71
Germany	12.5	87.5
United Kingdom	10	90
France	5.56	94.44

Note: This table summarizes the distribution of subsidiaries for which we make a large prediction error using the nightlight data relative to their reported economic activity. We use predictions based on Panel a of Figure 1. In each column we show the share of subsidiaries located in each country in our sample for which we make a large error and a share for which we do not. Top decile error indicates subsidiaries in the top 10th percentile of the distribution of the prediction error, deciles 4-7 indicates all those subsidiaries for which the error is relatively close to zero. We do not include countries for which no large errors are made in this table. Those are China, India, Poland, Italy, Czechia, Sweden, Korea, Portugal, Romania, Slovakia, Austria, Hungary, Morocco, Australia, Pakistan, Belgium, Colombia, Turkey, Finland, Iran, Algeria, Luxembourg, Peru, Serbia, Slovenia, South Africa, Switzerland.

Table C3: The distribution of firms in the top decile of the prediction error: countries.

	(1)	(2)	(3)	
	top decile of error	deciles 4-7	diff	t-test
avg. degree of urbanization in 5km radius	20.241	18.023	-2.218**	-2.132
% with urban center within 5km radius	0.771	0.714	-0.057	-0.701
average buildup in 5km ring around factory	31.457	20.344	-11.112***	-2.731
% with parking lot	0.486	0.400	-0.086	-0.900
% with industry park	0.457	0.464	0.007	0.075
% joint	0.200	0.086	-0.114	-1.574
number of factories per subsidiary	1.257	1.911	0.654***	2.825
Tax revenues as % of GDP	13.725	16.800	3.075***	3.860
GDP per capita	27154.504	23295.500	-3859.004	-1.016
Corporate tax rate	0.307	0.281	-0.025**	-2.027
% in high tax country	0.686	0.507	-0.179*	-1.980
Labor tax rate	21.040	30.677	9.636***	3.784
% in parent country	0.829	0.364	-0.464***	-6.074
(parent - subsidiary) corp tax rate	-0.001	-0.019	-0.018	-1.507
corp tax rate in parent	0.309	0.301	-0.008*	-1.812
% in the US	0.257	0.007	-0.250***	-3.320
Observations	35	140	175	

Note: This table summarizes the characteristics of subsidiaries for which we make a large prediction error using the nightlight data relative to their reported economic activity. We use predictions based on Panel a of Figure 1. Column 1 shows the average firm characteristics for subsidiaries for which we make a large error and column 2 shows the average firm characteristic for those that we do not make a large prediction error. Top decile error indicates subsidiaries in the top 10th percentile of the distribution of the prediction error, deciles 4-7 indicates all those subsidiaries for which the error is relatively close to zero. Column 3 shows the difference in means between these two groups and column 4 shows the t-test. ***, **, * denote significance at the 1%, 5%, and 10% levels, respectively.

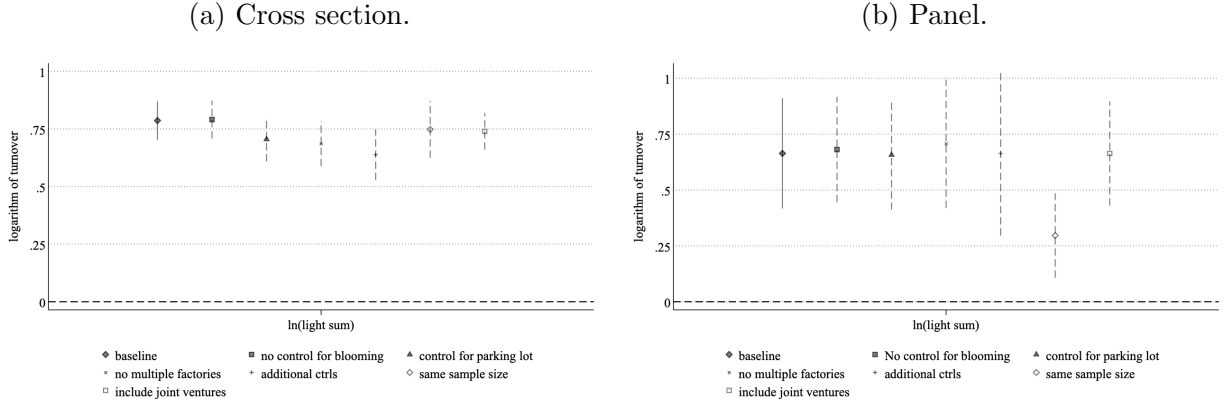
Table C4: Correlations between firm activities and nightlight.

	(1)	(2)	(3)
	log(turnover)	log(turnover)	log(turnover)
$\ln(N_i)$	0.773*** (0.039)	0.787*** (0.045)	0.705*** (0.064)
Parent FE	✓	✓	✓
Country-year FE	✓		
time-varying country controls		✓	
time-varying firm controls			✓
Observations	1450	1467	1494
R^2	0.715	0.559	0.598
R^2 within	0.510	0.504	0.547

Note: The table presents the correlation between firm activities, measured by the logarithm of firm turnover, and nightlight emissions using the Black Marble cleaning procedure. In all columns, we show results using annual data for 2012-2019. In column 1, we include country-year and parent fixed effects, in column 2 we include parent fixed effects and country-level time varying controls for GDP and GDP per capita, home and host corporate tax rates and host labor tax rate, in column 3, we include time-varying firm-level characteristics, such as presence of the parking lot, urbanization of the nearby area, presence of industry park, number of factories that belong to the plant. $\ln(N_i)$ is the logarithm of the total light emitted by a factory. In all specifications we control for the nightlight emitted within a 5 km radius around the factory excluding the factory itself. Robust standard errors are clustered at the country level. ***, **, * denote significance at the 1%, 5%, and 10% levels, respectively. R^2 within refers to the within variation, as indicated by the fixed effects included.

D Additional results

Figure D1: Testing the robustness of the baseline estimates.



Note: This figure tests the robustness of the baseline cross-sectional and panel estimates from columns 2 and 5 in Table 3. In each subfigure we plot the coefficient estimate for the relationship between the logarithm of total nightlight and logarithm of firm turnover. The first coefficient in each subfigure corresponds directly to the baseline from Table 3 and is labeled baseline. *No control for blooming* indicates that we do not include in the estimation the logarithm of nightlight emitted by the 5km radius around the factory, excluding the factory itself. *Control for parking lot* indicates that we include in the estimation the dummy for whether the factory has an adjacent assembly parking lot. *No multiple factories* indicates that we include in the estimation only observations where each subsidiary matched to exactly one factory. *Additional ctrls* indicates that in panel a, we include in the estimation controls for latitude, longitude, number of factories that belong to each subsidiary, the assembly parking lot dummy and the logarithm of nightlight emitted by the 5km radius around the factory, excluding the factory itself. In panel b, *Additional ctrls* indicates that we include in the estimation time-varying controls for corporate and labor tax rates in the country where the subsidiary is located, the buildup in the 5km radius from the factory, GDP per capita and tax revenues as % of GDP in the country where the subsidiary is located. *Same sample size* indicates that we include in the estimation only the firms for which we observe all the financial variables. *Include joint ventures* indicates that we include in the estimation factories that are owned by multiple car manufacturers and apportion the fraction of their ownership and consequently nightlight and financial operations equally to each car manufacturer. The vertical lines indicates 95% confidence intervals. Robust standard errors are clustered at the country level.

Table D1: Correlations between firm activities and nightlight, different clustering.

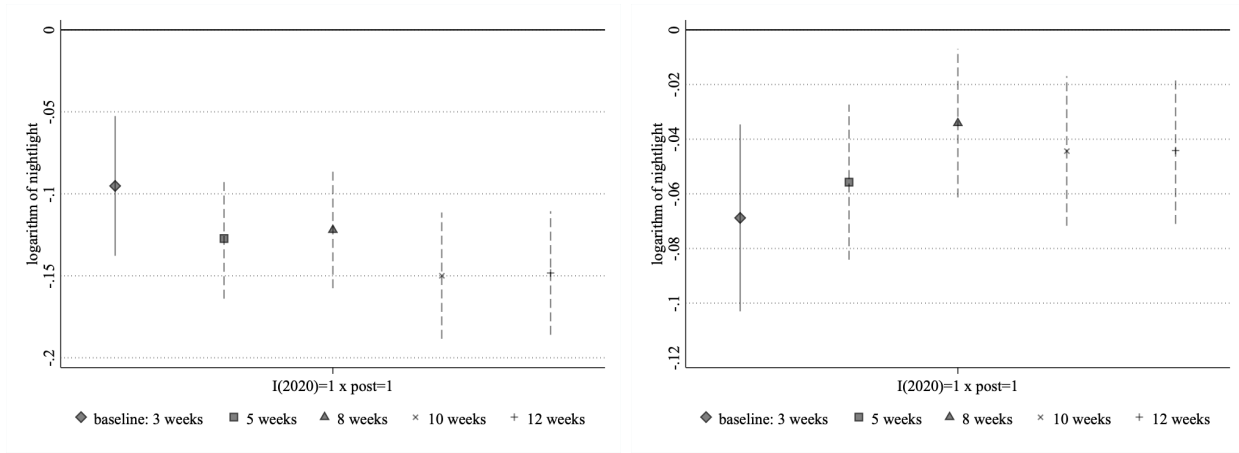
	Cross section		Panel		
	(1) ln(turnover)	(2) ln(turnover)	(3) ln(turnover)	(4) ln(turnover)	(5) ln(turnover)
$\ln(N_i)$	0.790*** (0.038)	0.786*** (0.077)	0.812*** (0.033)	0.791*** (0.055)	0.664*** (0.170)
Country FE		✓		✓	
Parent FE		✓		✓	
Firm FE					✓
Year FE					✓
Observations	320	309	1496	1484	1455
R^2	0.374	0.711	0.477	0.699	0.959
R^2 within	0.374	0.485	0.477	0.507	0.0990

Note: The table presents the correlation between firm activities, measured by the logarithm of firm turnover, and nightlight emissions using the Black Marble cleaning procedure. In columns 1 and 2, we show results for collapsed cross-sectional averages for 2012-2019. In columns 3-5, we show results using annual data for 2012-2019. $\ln(N_i)$ is the logarithm of the total light emitted by a factory. In all specifications we control for the nightlight emitted within a 5 km radius around the factory excluding the factory itself. Robust standard errors are clustered at the parent (car manufacturer) level. ***, **, * denote significance at the 1%, 5%, and 10% levels, respectively. R^2 within refers to the within variation, as indicated by the fixed effects included.

Figure D2: Testing the robustness of Covid-19 results: extend the time around the event.

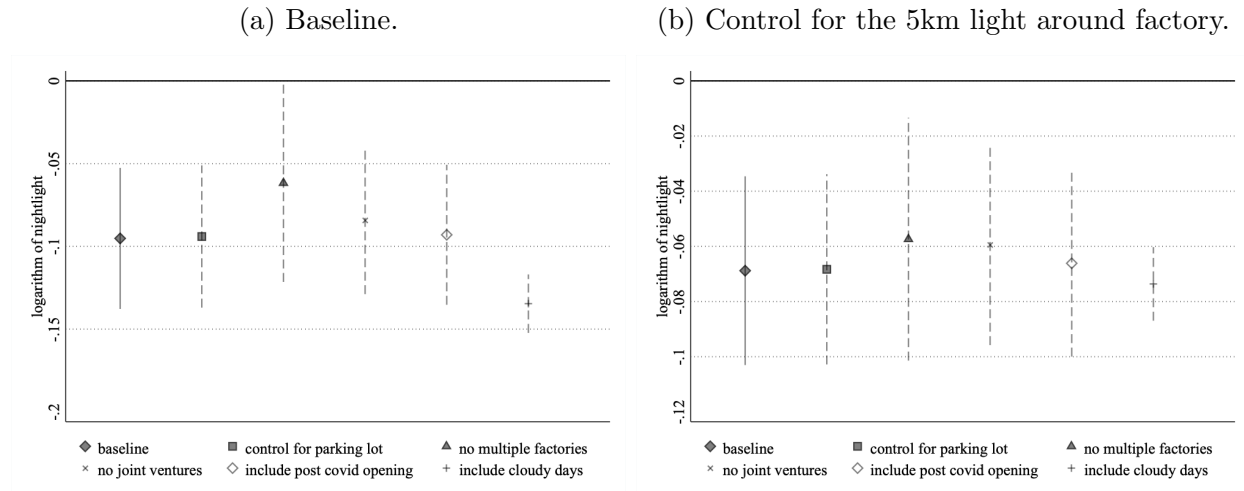
(a) Baseline.

(b) Control for the 5km light around factory.



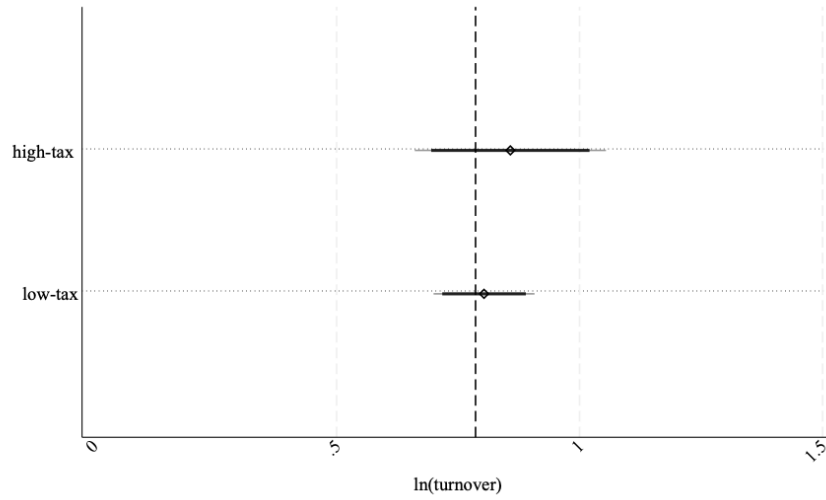
Note: This figure tests the robustness of the Covid-19 estimates from columns 1 and 2 in Table 5. Panel A results correspond to column 1, with the baseline: 3 weeks coefficient replicating the result. Panel B results correspond to column 2, with baseline: 3 weeks coefficient replicating the result. In each subfigure we plot the difference-in-differences coefficient on the interaction between $I(2020)$ dummy which indicates year 2020 and $\text{post}=1$ dummy which is 1 after the factory closed due to Covid-19. The dependent variable across all specifications is logarithm of total nightlight emitted by each factory. Squares correspond to results that use 5 weeks before and 5 weeks after the Covid-19 closure week, triangles for results using 8 weeks around Covid-19 closure week, cross markers for 10 weeks around Covid-19 closure week, and pluses for 12 weeks around Covid-19 closure week. The vertical lines indicates 95% confidence intervals. In each case we exclude observations for weeks after the factory re-opened at full capacity. Robust standard errors are clustered at the factory level.

Figure D3: Testing the robustness of Covid-19 results: sample restrictions.



Note: This figure tests the robustness of the Covid-19 estimates from columns 1 and 2 in Table 5. Panel A results correspond to column 1, with the baseline coefficient replicating the result. Panel B results correspond to column 2, with baseline coefficient replicating the result. In each subfigure we plot the difference-in-differences coefficient on the interaction between I(2020) dummy which indicates year 2020 and post=1 dummy which is 1 after the factory closed due to Covid-19. The dependent variable across all specifications is logarithm of total nightlight emitted by each factory. In each specification we include just one modification to the baseline estimate and in each case we plot coefficients for the period of 3 weeks before and 3 weeks after the factory closure week. Squares plot results that additionally control for the presence of an assembly parking lot next to the factory, triangles plot results that exclude factories that belong to the same subsidiary and that we later aggregate for the subsidiary-level analysis, cross markers plot results that exclude joint venture factories that are owned by the same car manufacturer, hollow diamonds plot results that include observations after the factory re-opened after Covid-19, pluses plot results where we additionally include observations for cloudy days that were originally excluded from the sample. The vertical lines indicates 95% confidence intervals. Robust standard errors are clustered at the factory level.

Figure D4: High vs low tax countries.



Note: The figure presents the correlation between firm activities measured by turnover and night-light emissions in high tax and low tax countries. Each dot plots a coefficient from estimating a regression of logarithm of turnover on $\ln(N_i)$, where the latter variable is defined as the logarithm of the total light emitted by a factory. We estimate each of these coefficients for the collapsed cross-sectional averages for 2012-2019 and include country and parent fixed effects. We cluster standard errors at the country level. The vertical line in each plot indicates the corresponding baseline average coefficient from column 2 in Table 3.