Impact of cyclones on manufacturing firms in India

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Online Appendix

Appendix A1. Cyclones included in the study and the districts affected

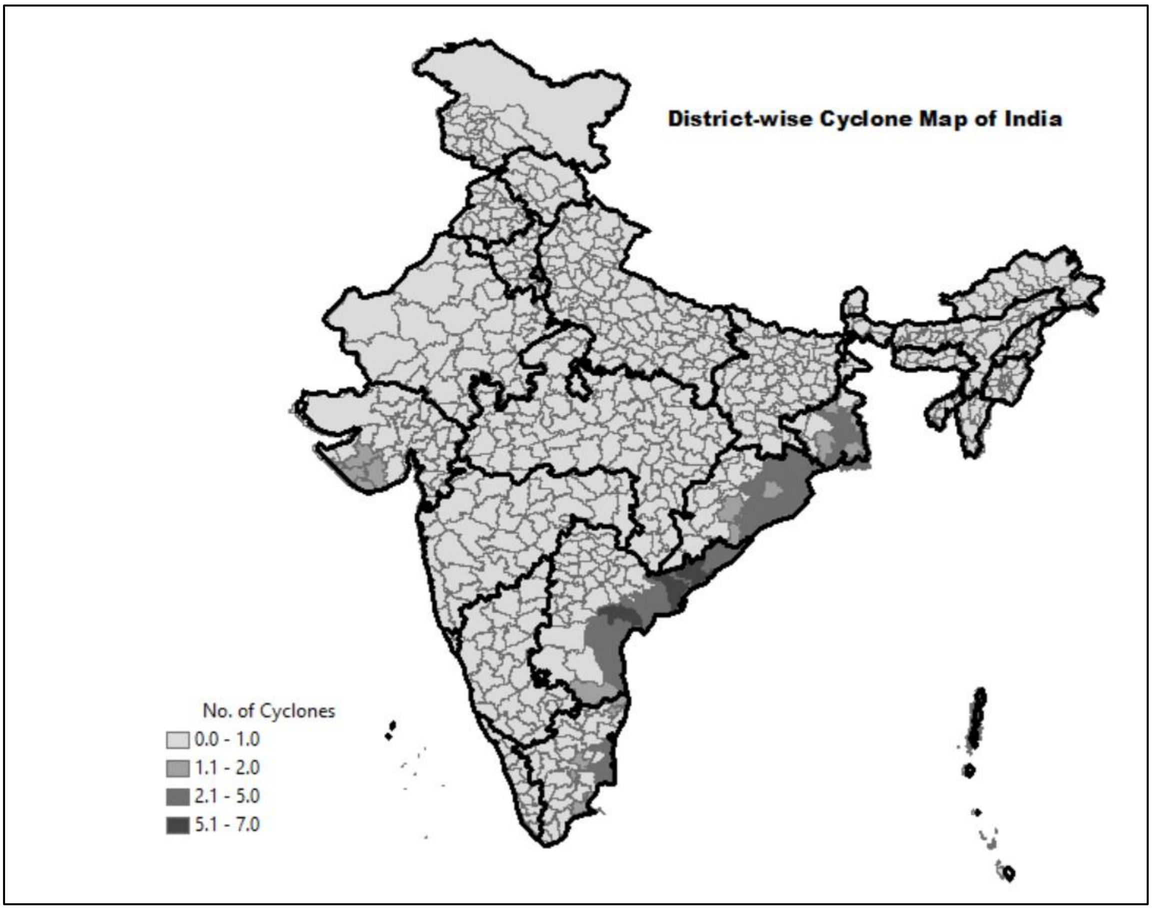
Twenty-three cyclones, listed in table A1, occurred during the period of our study, 2008–2019, and these cyclones are included in our study. State-wise, the count of the number of cyclones that affected them during 2008–2019 is as follows: Andhra Pradesh is the state that was most frequently affected by cyclones during the study period with seven cyclones, followed by Tamil Nadu (four cyclones) and Odisha (three cyclones). There were two cyclones each in Gujarat and West Bengal. There was one cyclone each during 2008–2019 in the following states/union territories (UTs): Assam, Dadra and Nagar Haveli, Daman and Diu, Kerala, Maharashtra, Manipur, Mizoram and Tripura. The districts of India impacted by cyclones are shown in Map A1.

Table A1. Cyclones included in the study

Year	Name of landfalling cyclone(s)	Of which, very severe and extremely severe cyclones: name of the cyclone and state(s)/ Union territories mainly affected (in parentheses)
2008	(i) Khai Muk; (ii) Nisha	
2009	(i) Aila; (ii) Phyan	
2010	(i) Laila; (ii) Jal	
2011	Thane	Thane (Tamil Nadu)
2012	Nilam	
2013	(i) Phailin; (ii) Helen	Phailin (Odisha)
2014	Hud Hud	Hud Hud (Andhra Pradesh)
2015	Komen	
2016	(i) Roanu; (ii) Vardha	Vardha (Tamil Nadu)
2017	(i) Mora; (ii) Ockhi	Ockhi (Gujarat)
2018	(i) Titli; (ii) Gaja; (iii) Pethai	Titli (Odisha); Gaja (Tamil Nadu), Pethai (Andhra Pradesh)
2019	Fani; Vayu; Maha; Bulbul	Bulbul (West Bengal); Fani (Odisha); Maha and Vayu (Gujarat, Daman and Diu, and Dadra and Nagar Haveli)

Note: Cyclonic storm (wind speed 62–87 km/h), severe cyclonic storm (wind speed 88–117 km/h), very severe cyclonic storm (wind speed 118–167 km/h), extremely severe cyclonic storm (wind speed 168–221 km/h) and super cyclone (wind speed more than 222 km/h). *Source:* https://mausam.imd.gov.in/imd_latest/contents/pdf/cyclone_sop.pdf.

Source: Prepared by the authors using diverse sources, including annual reports on 'Disastrous Weather Events' complied by the India Meteorological Department (IMD), Pune, Government of India.



Map A1. Cyclone frequency map of India by districts (2008–2019).
Source: Prepared by authors using data explained in the paper.

Many manufacturing plants in India are in coastal states, thus, vulnerable to cyclones. Coastal states accounted for about 70 per cent of fixed assets of organized manufacturing, and about two-thirds of gross value added in 2019–20. These estimates are based on the *Annual Survey of Industries* (ASI) (National Statistical Office, Ministry of Statistics and Programme Implementation, Government of India.) Drilling down further into the organized sector manufacturing data from ASI, it is found that the coastal districts account for a significant part of fixed assets and output of Indian manufacturing – 36 per cent of fixed assets and 35 per cent of gross value added in organized manufacturing in 2008–09. Such data on district-wise location of factories are available for 2008–09, but not for later years. Hence, an estimate for a recent year could not be presented.

Appendix A2. Single-establishment versus multi-establishment firms

The issue of single-establishment firms versus multi-establishment firms in the context of the present study has been raised in sections 1 and 2 of the paper. This is discussed further in this appendix. For single-establishment firms, the location of the plant is known, and therefore, the impact of cyclones can be ascertained more easily. If multi-plant firms are included in the analysis, this would give rise to data heterogeneity and thus lead to problems in the econometric estimation of models.

The single-establishment firms are commonly smaller in size. If we confine our analysis to the single-establishment firms, then only about a quarter of the manufacturing sector sales will be covered (see figure A1). Single-establishment firms account for about 70 per cent of the total number of manufacturing firms (within the dataset used) and account for about one-quarter of sales. If we additionally include all multi-plant firms, the coverage will be complete, but our regression results will be affected by the issue of cyclones' effect being heterogeneous among firms. To achieve a balance, single-establishment firms and firms with two or three plants have been included in the study. These firms together account for about 50 per cent of the sales of corporate manufacturing.

Size distribution of manufacturing firms

The distributions of manufacturing firms according to the value of sales and total assets in 2019 are depicted in figures A2 and A3. A comparison is made in the distributions for three categories of firms: (a) single-establishment firms, (b) firms having three or fewer plants, all of which are in the same state, and (c) other firms. There is a high concentration of firms (about three-quarters) in the size classes of (a) up to Rs1 billion (≈ US$14 million) and (b) Rs1–3 billion (≈ US$14–42 million) in sales and total assets.

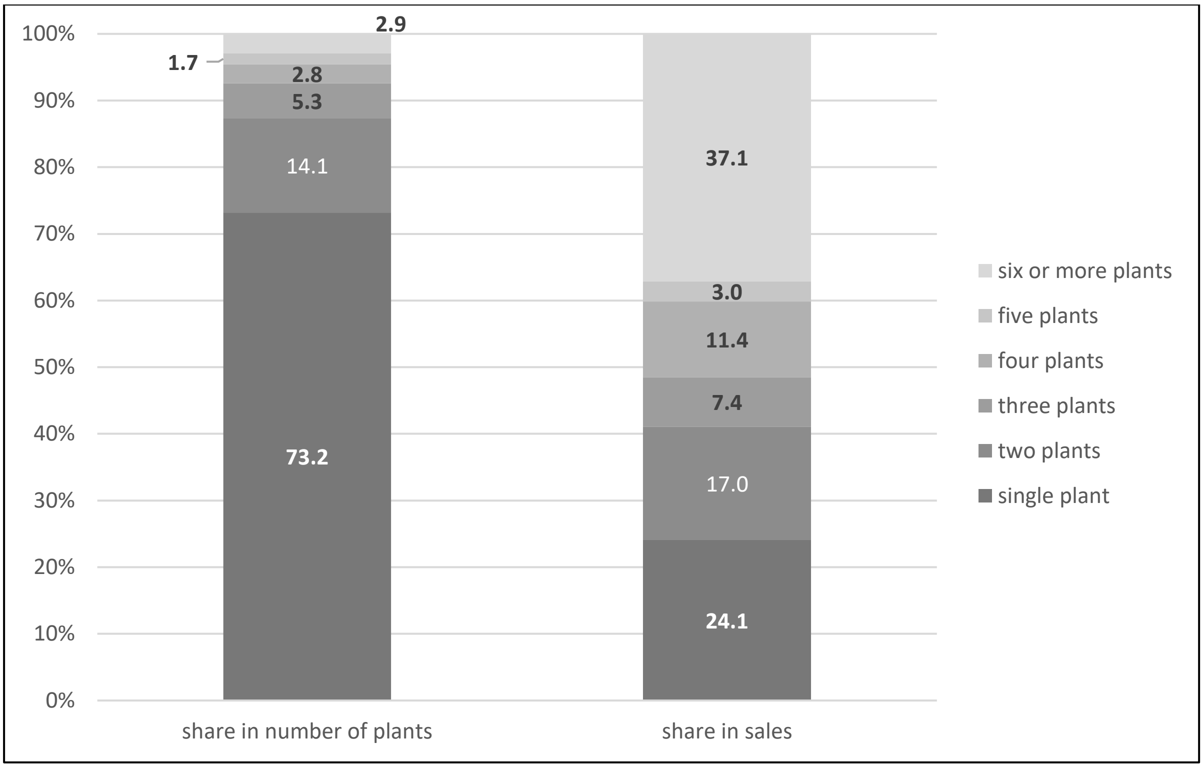


Figure A1. Manufacturing firms and plants, 2019–20, share in sales and total number of plants (%).

Source and note: Authors' computations based on the Prowess database. The shares are out of the total number of plants belonging to the manufacturing firms in the Prowess database, and the total sales of those firms.

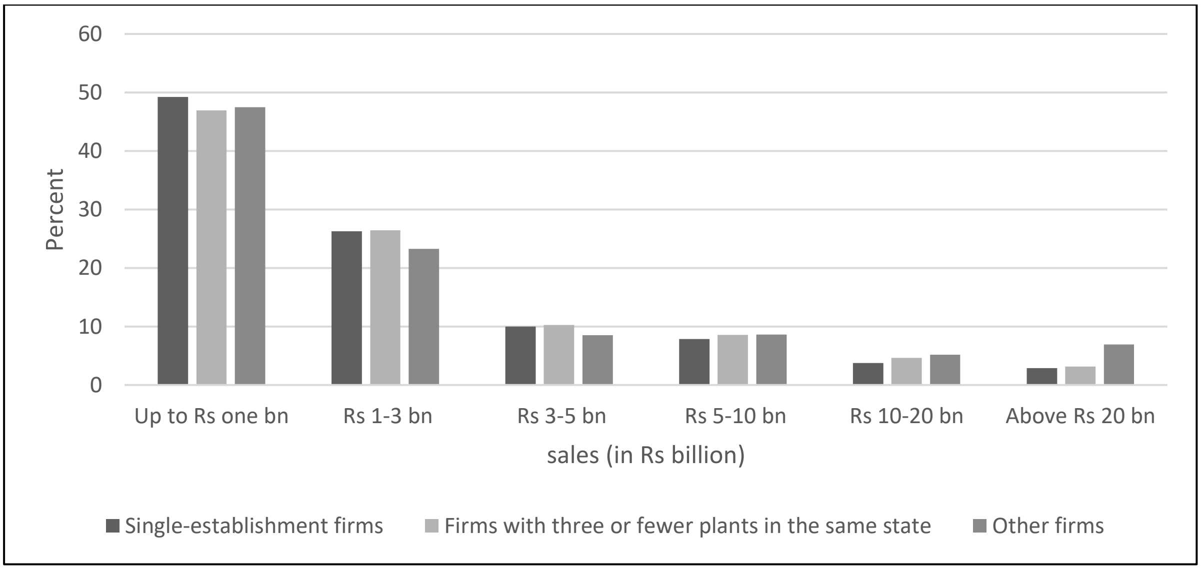


Figure A2. Percentage distribution of manufacturing firms according to sales in 2019.

Note: The exchange rate in 2019 was approximately US$1 = Rs70.4.
Source: Authors' computations from the Prowess database.

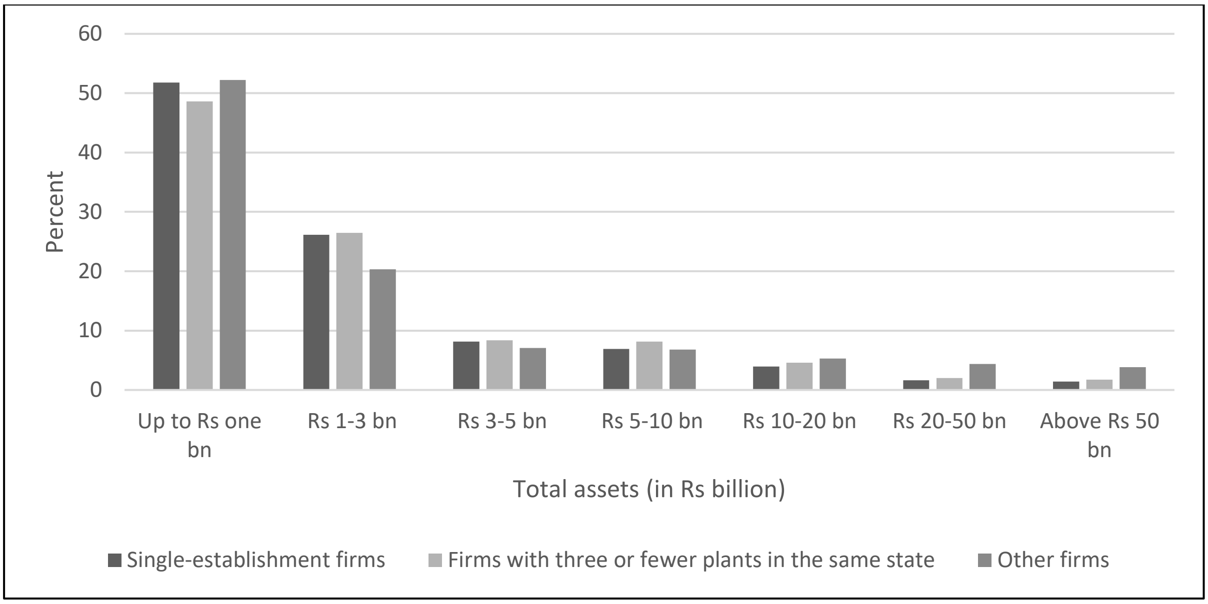


Figure A3. Percentage distribution of manufacturing firms according to total assets in 2019.

Source: Authors' computations from the Prowess database.

Variation in sales and assets among firms with different number of plants

The mean values of the two performance variables considered in the study, viz. sales and the real value of total assets, in different categories of manufacturing firms are shown in table A2 along with standard deviation. The data are at current prices and relate to 2019–20. The firms having four or more plants have a relatively high value of sales and assets. Such firms are excluded from the analysis for the reasons explained above.

Table A2. Some data on sales and total assets of manufacturing firms in Prowess, 2019

Firm category	Sales (Rs billion)		Total assets (Rs billion)	
	Mean	Std. dev.	Mean	Std. dev.
All manufacturing firms	7.8	90.1	8.1	112.8
Firms having 4 or more plants	58.6	339.0	78.0	474.1
Firms having 3 or fewer plants	6.3	53.3	6.1	35.8
Firms having 3 or fewer plants in the same state	4.6	27.1	4.6	24.3
Firms having a single plant	4.1	25.4	4.1	22.6
Firms having 2 or 3 plants not in the same state	15.8	120.1	14.5	72.2

Note: The exchange rate in 2019 was approximately US$1 = Rs70.4. The first row includes companies for which details of plants are not available.
Source: Authors' computations based on Prowess.

Portion of Indian manufacturing is covered by Prowess

The analysis of the impact of cyclones on Indian manufacturing presented in the paper is based on the Prowess database. Does it adequately capture or represent the losses suffered by Indian manufacturing?

It should be noted that manufacturing firms covered in the Prowess database account for about 60–70 per cent of the economic activity of organized manufacturing in India and most of the capital stock of organized manufacturing. This makes an analysis based on the Prowess database useful for understanding how cyclones impact Indian manufacturing. There are about 0.2 million active manufacturing companies in India (based on data of the Ministry of Corporate Affairs, Government of India). The manufacturing companies covered in the Prowess database form less than five per cent of the number of active manufacturing companies, but account for the dominant portion of turnover and assets of corporate manufacturing. Outside corporate manufacturing, there are organized sector proprietorship and partnership firms engaged in manufacturing which are about 0.1 million in number. In addition, there are about 17.8 million manufacturing enterprises (establishments) in the unorganized unincorporated sector. While the present study covers only a very small portion of the total number of manufacturing enterprises in India, these enterprises dominate Indian manufacturing.

Appendix A3. Information about ASI frame

The ASI[1] frame contains the list of all live industrial units with addresses from which samples are drawn for yearly surveys. The lists are updated by considering new entries and exits of plants. This frame for different years has been used to study the impact of cyclones on the probability of firm closure in manufacturing.

[1] ASI covers industrial units with 10 workers or more with power, or 20 workers or more without power.

The frame for 2013–14 (hereafter, 2013) contains information for about 220 thousand plants. The number of plants in the frame has increased over time. Over 90 per cent of the plants in the frame belong to manufacturing. To keep our work manageable (since we have worked on such large datasets for several years), we confined our attention to manufacturing plants in the frame in 2013 and their journey thereafter. We ignored new entries into the frame and how long such factories survived.

Out of all manufacturing plants (hereafter, plants) existing in 2013, slightly less than half could not be found in the frame for 2020. These plants were removed from the frame during 2014–2020, or there was a change in ownership, or a change in the name including a slight change in the name, or other issues because of which our computer algorithm could not match the plants in the two such large lists of names and addresses. Perhaps the actual business-failure-related attrition was about a third or a little higher. Such high business failure rates are not unexpected because relatively small plants dominate the frame. The data from the ASI frame for 2013–14 shows that 55 per cent of the plants had employment of 20 persons or less, and about 80 per cent had employment of 50 persons or less. Only about three per cent of the plants employed more than 500 persons. The average employment among all plants in the ASI frame was about 92 persons.

Appendix A4. Cyclones' impact on sales – influence of firm size and number of plants

The analysis presented in table 1 of the paper indicates that small-sized manufacturing firms suffer a significant loss in sales due to cyclones, but the effect of cyclones on the sales of relatively much bigger multi-plant firms with plants in different states might be small or even marginal. To confirm these findings regarding the effect of cyclones on sales of manufacturing firms, Reg-3 in table 1 has been re-estimated after introducing intercept and slope dummies for size classes. The entire set of firm-year observations has been divided into three (equal) parts based on the real value of total assets, and three firm-size class dummy variables have been constructed (Size-1, Size-2, and Size-3). The two dummy variables Size-2 and Size-3, and the interaction terms formed by multiplying these dummy variables by the dummy variable for cyclones have been introduced into the model (equation (3)).[2] The equation has been estimated for firms having 1–3 plants in the same state. The regression results are presented in table A3.

It is seen in the results in table A3 (Reg-A1) that among the bottom one-third of firms in terms of size, cyclones cause a decline in real sales by about 10 per cent. For the middle one-third, cyclones cause a decline in real sales by about six per cent. For the top one-third, the sum of coefficients [Cof-1] and [Cof-3] is about (–)0.03, which is found to be statistically insignificant. The results are similar in Reg-A2. These findings corroborate the finding from table 1 that for big-sized firms, the effect of cyclones on their sales might be small or marginal. This inference is reinforced by the results reported in Reg-A3. It is seen in these results that for firms with three plants, the impact of cyclones on sales, obtained by adding Cof-6 and Cof-7 is positive, and the estimate is also statistically significant.

[2] Size-1 becomes the excluded or base category. All three dummies cannot be included in the regression.

Table A3. Regression results, explaining real sales, fixed-effects model, firms with 1–3 plants in the same state, alternate specification

Dependent variable: logarithm of real sales

Explanatory variables	Reg-A1	Reg-A2	Reg-A3
Cyclone dummy	–0.092(0.030)[Cof-1]	–0.080(0.030) [Cof-4]	–0.046(0.014)[Cof-6]
Size class 2 (dummy)	0.275(0.022)	0.270(0.021)	
Size class 3 (dummy)	0.635(0.028)	0.624(0.025)	
Size class 2 (dummy) × cyclone dummy	0.042(0.043) [Cof-2]	0.046(0.045)	
Size class 3 (dummy) × Cyclone dummy	0.064(0.041) [Cof-3]	0.063(0.041) [Cof-5]	
two plants (dummy) × Cyclone dummy			-0.001(0.043)
three-plants (dummy) × Cyclone dummy			0.133(0.028) [Cof-7]
OFDI intensity	2.155(0.832)	2.064(0.855)	2.766(0.914)
Logarithm of lagged labour productivity	0.375(0.020)	0.378(0.020)	0.387(0.020)
Logarithm of age	1.018(0.101)	0.993(0.115)	1.042(0.119)
Lagged export intensity	0.151(0.036)	0.142(0.038)	0.163(0.039)
Joint test of the above nine coefficients (7 for A3) (null hypothesis: all equal to zero); F-ratio and prob.	234.0 (0.000)	203.6 (0.000)	87.8 (0.000)
State-by-year dummy variables	Yes	Yes	Yes
Industry-by-year dummy variables	No	Yes	Yes
R-squared, within	0.27	0.29	0.26
R-squared, overall	0.22	0.23	0.07
No. of observations	37,537	37,537	37,537

Notes: (1) Robust standard errors clustered at the state level in parentheses. State-by-year dummy variables are included. In some regressions, industry-by-year dummies are included. (2) Size classes are explained in the text. The sum of Cof-1 and Cof-2 is the impact of cyclones on the sales of middle-size firms. This is negative and statistically significant at the five per cent level. The sum of Cof-1 and Cof-3 is the impact of cyclones on the sales of big-sized firms (top one-third). This is about (–)0.03 in numerical value and is statistically insignificant. The F-statistic for the test is 1.89 and the corresponding probability is 0.18. In the case of Reg-A2, the sum of Cof-4 and Cof-5 is (–)0.017. This is not statistically significant. The F-statistic is 0.51 and the probability is 0.48. (3) In Reg-A3, dummy variables for firm with two plants and for firms with three plants get dropped from the regression because a fixed-effects model is estimated. The sum of Cof-6 and Cof-7 is positive and statistically significant at the one per cent level.
Source: Authors' computations based on the Prowess database.

Appendix A5. Impact of cyclones on total assets, results based on the difference-in-difference estimator

To check the robustness of the results obtained by regression analysis, presented in table 2, we have taken an alternative approach to study the impact of cyclones on the assets of industrial firms and have applied the difference-in-difference (DiD) method. The estimates of the effect of cyclones on the total assets of manufacturing firms obtained by applying the DiD estimator are shown in table A4. The quintile DiD estimator is used for the analysis (on the ground that we have found from a preliminary analysis that the distribution of ΔlnK is much different from a normal distribution; see footnote 8 in section 4.2.2 of the paper). The following covariates have been used to obtain the DiD estimates: the profit margin, i.e., the ratio of profits to sales, and the lagged value of the debt-equity ratio.

In the results obtained, the DiD estimate for ΔlnK, i.e., the growth in total assets, is negative and statistically significant. Thus, the DiD estimate for ΔlnK in table A4 is consistent with the regression results presented in table 2. The results provide grounds to infer that cyclones cause a reduction in the value of total assets of manufacturing firms by about 1.4 to 2.1 per cent, which is by and large consistent with the estimates in table 2.

Table A4. Impact of cyclones on growth rates in total assets: DiD estimates, 2008–2019

Firm category and Parameter	Firms with a single plant	Firms with 1–3 plants
Before: firms not having plants affected by cyclones	0.051	0.052
Before: firms having plants affected by cyclones	0.042	0.045
After: firms not having plants affected by cyclones	0.040	0.042
After: firms having plants affected by cyclones	0.018	0.014
DiD estimate	–0.014	–0.021
Standard error and probability in brackets	0.006 [0.030]	0.005 [0.000]
Total observations used	52,451	73,073

Note: Each year from 2008 to 2019 is compared with the previous year. This is done for each firm, subject to data availability.
Source: Authors' computations from the Prowess database.

Appendix A6. Analysis of lagged impact of cyclones

The Econometric models used for the analysis of the impact of cyclones on sales and total assets of manufacturing firms have been specified in section 4.2.2 of the paper. To study the lagged impact of cyclones, lagged terms representing the dummy variable for cyclones have been introduced, and extended versions of equations (3) and (5) have been estimated.

In the estimates based on equation (3) in table 1, which explains real sales, C_{irt} is a dummy variable representing whether any plant of firm *i* in region *r* was affected by one or more cyclones in year *t*. Two lagged terms of the dummy variable have been introduced in the model to allow for a lagged impact of cyclones. The modified equation may be written as

$$lnS_{irt} = a_{ir} + \theta_{rt} + \beta_{S0}C_{irt} + \beta_{S1}C_{ir,t-1} + +\beta_{S2}C_{ir,t-2} + \sum_u \gamma^{\mu} Y^{u}_{irt} + \xi_{irt} \,. \qquad \text{(A1)}$$

This specification is similar in spirit to using current and lagged weather variables in a version of the model estimated by Deschênes and Greenstone (2011) to explain the impact of temperature on mortality, incorporating the temperature-mortality dynamics. We recognize that greater insight into the lagged impact of cyclones on firm performance could have been gained by using a dose-response function framework as discussed in Carleton and Hsiang (2016) or by carrying out an analysis in a treatment effect framework with event study design, allowing for distributed lags as discussed in Schmidheiny and Siegloch (2023). However, we have not attempted any such sophisticated analysis because the result of our analysis based on equation (A1) did not reveal a large, lagged impact of cyclones on firm performance occurring over several years.

In the equation we have used to assess the impact of cyclones on total assets, i.e., equation (5), the impact of cyclones is captured by ΔC_{it} and $\Delta C_{i,t-1}$. One period lagged impact is already included in the equation. For studying the lagged impact of cyclones over a longer period, $\Delta C_{i,t-2}$ and $\Delta C_{i,t-3}$, i.e., extension of lags by two more periods, have been added. The transformed equation may be written as

$$\Delta lnK_{it} = \lambda + \phi\,\Delta lnK_{i,t-1} + \beta_{K0}\Delta C_{it} + \beta_{K1}\Delta C_{i,t-1} + \beta_{K2}\Delta C_{i,t-2} + \beta_{K3}\Delta C_{i,t-3} + \sum_u \phi^u \Delta W^u_{it} + \sum_u \pi^u \Delta W^u_{i,t-1} + \varphi_{it}\,. \quad \text{(A2)}$$

This equation is akin to a regression capturing the dynamic cumulative treatment effect Schmidheiny and Siegloch (2023: 702). Also, the equation bears some resemblance to the equation used by Romer and Romer (2020: 780), linking change in output to past stream of tax changes and past increases in output.

Table A5 shows the estimates of equation (A1). A significant lagged impact of cyclones on sales is not found when the results for single-establishment firms are considered. However, in the results for a more extensive set of firms, including those having up to three plants in the same state, a significant lagged impact of cyclones on sales is found.

Table A5. Regression results, explaining real sales, fixed-effects model, firms with a single plant or 1–3 plants in the same state, allowing for the lagged impact of cyclones

Dependent variable: logarithm of real sales

Explanatory variables	Reg-A4	Reg-A5
	Firms with a single plant	Firms with 1–3 plants in the same state
Cyclone dummy	–0.072 (0.025)	–0.074 (0.013)
Cyclone dummy (*t*-1)	–0.032 (0.038)	–0.034 (0.014)
Cyclone dummy (*t*-2)	–0.060 (0.038)	–0.055 (0.045)
OFDI intensity	2.633 (1.354)	2.965 (0.963)
Logarithm of lagged labour productivity	0.370 (0.024)	0.364 (0.023)
Logarithm of age	1.216 (0.123)	1.223 (0.162)
Lagged export intensity	0.170 (0.049)	0.155 (0.040)
Joint test of the above five coefficients; F-ratio and prob.	48.0 (0.000)	23.0 (0.000)
R-squared, within	0.24	0.23
R-squared, overall	0.05	0.05
No. of firms	3,944	4.447
No. of observations	26,930	30,711

Notes: Robust standard errors clustered at the district and state levels in Reg-A4 and Reg-A5, respectively, shown in parentheses. State-by-year dummy variables are included.
Source: Authors' computations based on the Prowess database.

Since the two sets of results disagree, it is difficult to draw any definite conclusion about the lagged impact of cyclones on real sales. Perhaps there is no lagged impact, or, maybe there is a one-period lagged impact of cyclones on sales. Considering the numerical values of the coefficients for the current year's impact and the lagged impact next year, it may be inferred that the total impact on sales is a negative 10 per cent.

Table A6 shows the estimates of equation (A2). Estimates of equation (5) (see section 4.2.2 of the paper) are also presented to facilitate a comparison. Reg-A8 and Reg-A9 allow for the lagged impact of cyclones beyond what is considered in Reg-A6 and Reg-A7 based on equation (5). The results show that the two-period lagged, and three-period lagged terms are not statistically significant. Thus, the results in table A6 indicate that cyclones have at most one-period lagged impact on assets, which is an assumption underlying the estimation method employed.

Appendix A7. Principal component analysis, trade-technology orientation

An index of trade-technology orientation has been formed by applying principal component analysis (PCA). For this purpose, four variables have been considered: R&D intensity (R&D expenditure to sales ratio), technology import intensity (that is, expenditure on royalty and technical knowhow incurred in foreign exchange divided by sales), capital goods import intensity (imports of capital goods divided by sales), and materials import intensity (imports of raw materials, stores and spares divided by total expenses on raw materials, stores and spares (see figure A4 which gives an indication of the technology acquisition and import activities of firms). The four variables considered have a positive correlation with one another – correlation coefficient ranging from 0.035 between R&D intensity and technology import intensity and between R&D intensity and capital goods import intensity to 0.17 between materials import intensity and technology import intensity and between materials import intensity and capital goods import intensity. This index has been constructed by taking the first principal component obtained after applying principal component analysis and is called the trade-technology orientation index in the paper.

Table A6. Estimates of the model explaining real capital stock, first-differenced instrument variable (FD_IV) Regression, allowing for the lagged impact of cyclones

Dependent variable: logarithm of the real value of total assets (first-differenced)

Explanatory variables	Firms with a single plant Reg-A6	Firms with 1–3 plants Reg-A7	Firms with a single plant Reg-A8	Firms with 1–3 plants Reg-A9
ΔlnK_{t-1}	0.406	0.399	0.377	0.351
	(0.026)	(0.025)	(0.028)	(0.019)
ΔCyclone	–0.014	–0.015	–0.017	–0.020
dummy(C)	(0.007)	(0.004)	(0.007)	(0.005)
ΔC_{t-1}	–0.008	–0.009	–0.018	–0.018
	(0.006)	(0.004)	(0.008)	(0.006)
ΔC_{t-2}			–0.008	–0.010
			(0.010)	(0.007)
ΔC_{t-3}			–0.005	–0.005
			(0.009)	(0.006)
ΔDE	–0.0027	–0.0027	–0.0030	–0.0029
	(0.0005)	(0.0004)	(0.0005)	(0.0003)
ΔDE_{t-1}	–0.0022	–0.0018	–0.0020	–0.0017
	(0.0005)	(0.0004)	(0.0005)	(0.0004)
ΔPR	0.110	0.120	0.102	0.115
	(0.011)	(0.011)	(0.012)	(0.006)
ΔPR_{t-1}	0.049	0.048	0.045	0.046
	(0.012)	(0.011)	(0.011)	(0.007)
Δlnklr	–0.078	–0.074	–0.078	–0.073
	(0.009)	(0.008)	(0.010)	(0.005)
$\Delta lnklr_{t-1}$	–0.002	–0.004	–0.001	–0.005
	(0.003)	(0.003)	(0.003)	(0.003)
Constant	0.032	0.035	0.028	0.032
	(0.002)	(0.002)	(0.002)	(0.002)
No. of observations	19,352	27,318	15,805	22,173
No. of firms	3,377	4,549	3,149	4,257
R-squared (overall)	0.97	0.98	0.97	0.97
Wald chi-square,	371.6	560.7	600.0	911.6
and prob.	(0.000)	(0.000)	(0.000)	(0.000)

Notes: Robust standard errors clustered at the district level in Reg-A6 and Reg-A8 and at the firm level in Reg-A7 and Reg-A9, shown in parentheses. Observations in which Δ*lnK* is more than 2 or less than (–2) have been dropped.
Variable notation: lnK = log of the real value of total assets; C = Cyclone dummy; DE = Debt-equity ratio (lagged); PR = Profit (PBDITA) by sales; *lnklr* = Capital-labour ratio (in logarithms, one year lagged).
Source: Authors' computations based on the Prowess database.

The factor loadings for the first principal component are 0.32 for R&D intensity, 0.51 for technology import intensity, 0.50 for capital goods import intensity, and 0.63 for materials import intensity. With all four positive factor loadings, the interpretation of this component is that it represents the trade and technology orientation of the firms. The index constructed bears a positive correlation with export intensity (correlation coefficient = 0.17) and with the degree of information technology use (correlation coefficient = 0.11), which lends further support to the interpretation of the index formed as being reflective of trade-technology orientation.

The index of trade-technology orientation bears a positive relationship with firm size. The correlation coefficient between the index and the logarithm of the real value of total assets is 0.22.

The first component has an eigenvalue of 1.32. This is the only component out of four components that has an eigenvalue above unity. This component explains about 33 per cent of the variation.

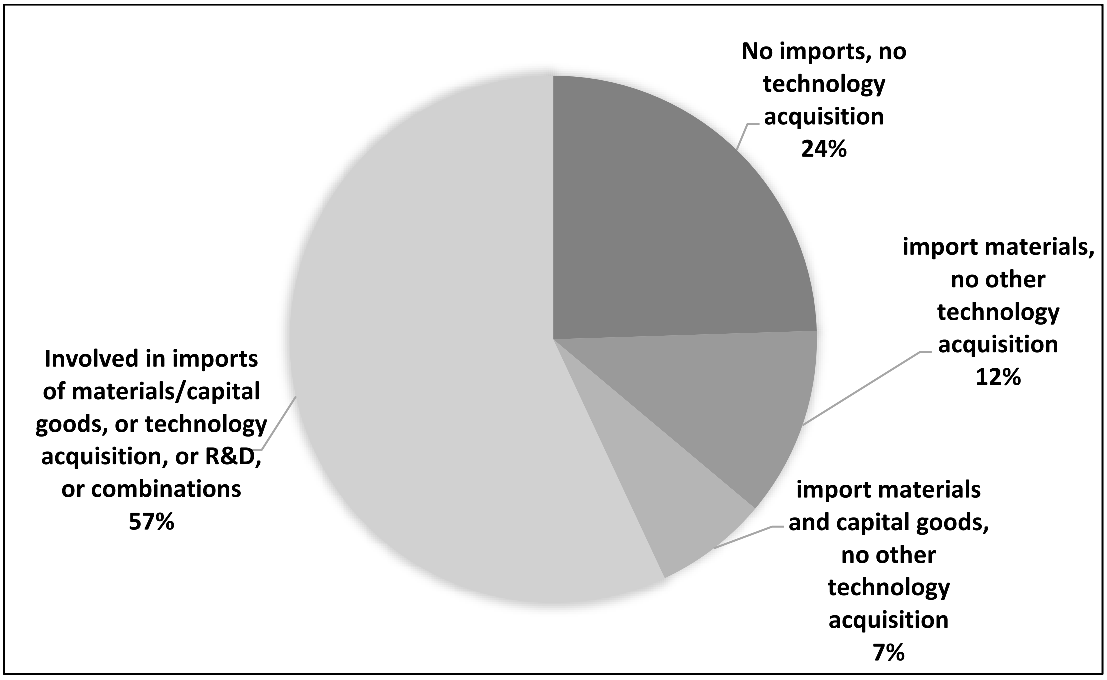


Figure A4. Distribution of firms by import activity and technology acquisition.
Source: Authors' computations based on the Prowess database.

Appendix A8. Influence of firms' trade-technology orientation on cyclone impact

The construction of the trade-technology index of the firms has been explained in appendix A7. Based on the trade-technology orientation index, firms (observations) have been divided into two groups, taking the 67th percentile has been taken as the cut-off. Thus, the bottom two-thirds of the firm (or observations) in terms of the index have been included in one set, and the upper one-third have been taken in the other. Then, equations (3) and (5) have been estimated separately for these two groups of firms (observations). The results obtained by estimating equation (3), separately for the two groups are discussed in section 6.4 of the paper. The results obtained by estimating equation (5) for the two groups which shows the impact of cyclones on capital stock are presented in table A7.

The results in table A7 deal with the question of whether the trade-technology orientation of a firm makes a difference in the effect of cyclones on the total assets of the firm. The analysis is undertaken separately for single-plant firms and firms with up to three plants. In Reg-A10 and Reg-A12, the coefficient of the cyclone dummy is negative and statistically significant. The results show that cyclones cause a fall in the value of total assets in firms that have a low trade-technology orientation (matching the results in table 3).

In Reg-A11, the coefficient of the dummy for cyclones is statistically insignificant, and in Reg-A13 which includes more firms (and bigger firms) in addition to those covered in Reg-A11, the coefficient is negative but statistically significant only at the 10 per cent level. Thus, the results indicate that cyclones do not cause a dip in the capital stock of firms with high trade-technology orientation. In this regard, the results for capital stock are similar to those for real sales.

Table A7. Estimates of the model explaining real capital stock, FD-IV regression, distinguishing according to trade-technology orientation

Dependent variable: logarithm of real total assets (first-differenced)

Explanatory variables	Firms with a single plant Reg-A10	 Reg-A11	Firms with 1–3 plants Reg-A12	 Reg-A13
	Having a relatively lower trade-technology orientation	Having a relatively higher trade-technology orientation	Having a relatively lower trade-technology orientation	Having a relatively higher trade-technology orientation
ΔlnK_{t-1}	0.424 (0.036)	0.260 (0.054)	0.387 (0.033)	0.339 (0.044)
ΔCyclone dummy (C)	–0.015 (0.007)	–0.011 (0.010)	–0.016 (0.005)	–0.012 (0.007)
ΔC_{t-1}	–0.007 (0.009)	–0.005 (0.008)	–0.008 (0.006)	–0.007 (0.007)
ΔDE	–0.0031 (0.0007)	–0.0007 (0.0008)	–0.0029 (0.0005)	–0.0013 (0.0006)
ΔDE_{t-1}	–0.0023 (0.0006)	–0.0016 (0.0007)	–0.0020 (0.0006)	–0.0019 (0.0006)
ΔPR	0.128 (0.013)	0.114 (0.024)	0.142 (0.014)	0.139 (0.025)
ΔPR_{t-1}	0.053 (0.013)	0.075 (0.025)	0.051 (0.014)	0.067 (0.023)
Δlnklr	–0.076 (0.012)	–0.061 (0.015)	–0.072 (0.009)	–0.066 (0.014)
$\Delta lnklr_{t-1}$	0.001 (0.004)	–0.004 (0.005)	–0.002 (0.004)	–0.001 (0.004)
Constant	0.027 (0.003)	0.047 (0.004)	0.030 (0.002)	0.044 (0.004)
No. of observations	11,946	5,089	15,773	8,232
R-squared	0.97	0.96	0.97	0.98
Wald chi-square, and prob.	267.0 (0.000)	70.4 (0.000)	345.3 (0.000)	155.9 (0.000)

Notes: Robust standard errors, clustered at the district level in Reg-A10 and Reg-A11 and at the firm level in Reg-A12 and Reg-A13, are shown in parentheses. Observations in which Δ*lnK* is more than 2 or less than (–2) have been dropped. The measure of trade and technology orientation is discussed in the text and appendix A7. The two groups are formed by taking the bottom 67% and the top 33%.
Variable notation: lnK = log of the real value of total assets; C = Cyclone dummy; DE = Debt-equity ratio (lagged); PR = Profit (PBDITA) by sales; *lnklr* = Capital-labour ratio (in logarithms, one year lagged).
Source: Authors' computations based on the Prowess database.

Additional analysis of the influence of trade-technology orientation on cyclones' impact

Figure A5 presents estimates of the effect of cyclones on real sales for different categories of firms. The question of interest is which type of firms can withstand better the adverse effect of cyclones on their sales, looking particularly into the role of trade-technology orientation. The estimates have been made by estimating equation (3) (see section 4.2.2) after adding intercept and slope dummies for firm categories based on various trade and technology related variables (one aspect considered at a time).

The estimates shown in figure A5 show that the adverse effect of cyclones on sales is relatively less for firms engaged in R&D or technology imports or both, and for firms that are importing capital goods. It is substantially lower for firms that have relatively higher use of information technology and information technology enabled services – through their investment in computers, etc., or through expenditure incurred on the purchase of such services from other agencies or both. Similarly, the firms participating in global value chains (GVCs) are relatively less affected by cyclones than those not participating in GVCs. The following definition is used for GVC participation. A firm is considered to be engaged in GVCs if (i) the share of exports in sales is at least one per cent and the share of imported raw materials, stores and spares is at least one per cent of the total value of raw materials, stores and spares consumed, with the added condition that (ii) either the share of exports in sales is 10 per cent or more, or the share of imports of raw materials, stores and spares in the total value of raw materials, stores and spares used is 10 per cent or more (or both).

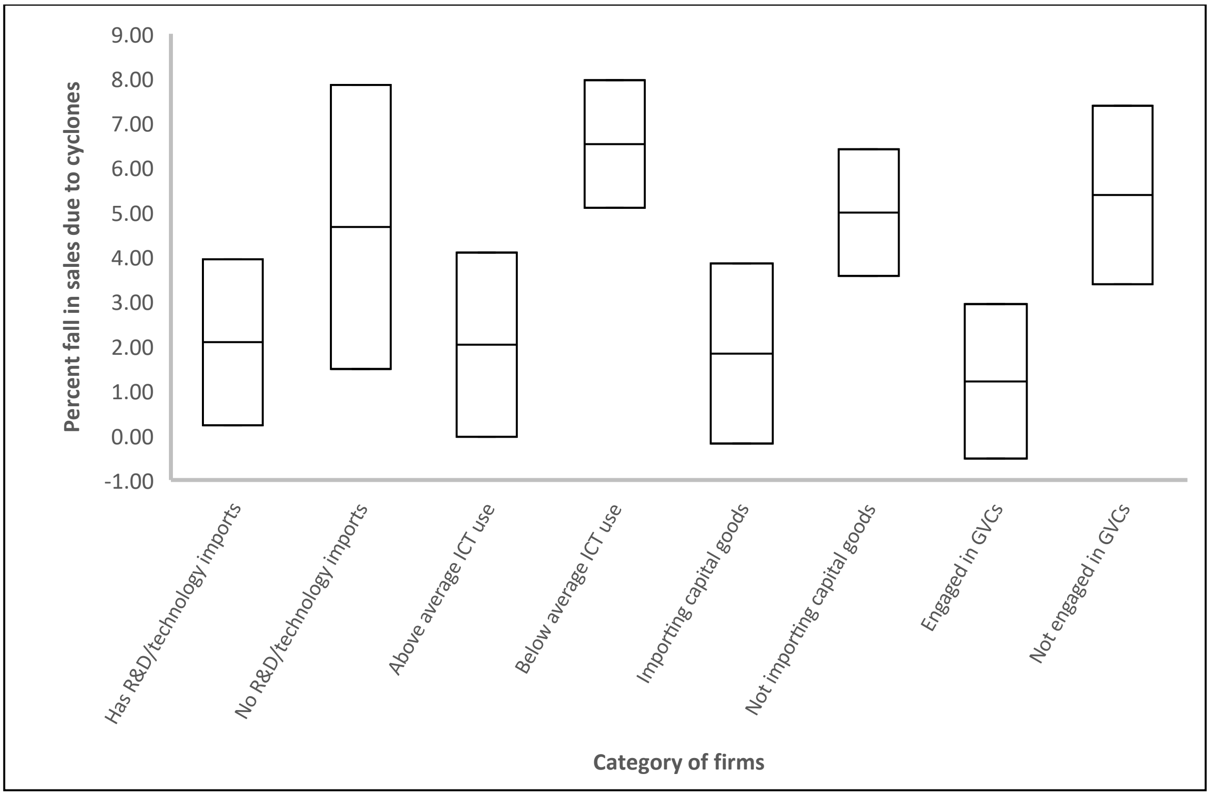


Figure A5. Reduction in real sales (%) because of cyclones, link with trade-technology orientation.

Note: The *y*-axis shows the extent of fall. The analysis confined to firms having 1–3 plants, all located in the same state/UT. The differential effect of cyclones on real sales of firms is estimated by using intercept and slope dummies (applied to equation (3)). The middle line in the box is the estimate. The box shows the band formed by taking plus/ minus one-time standard error.
Source: Authors' computations based on the Prowess database.

While the graph shown above gives the impression that cyclones' impact on sales differs between the firms that participate in GVCs vis-à-vis the firms that do not participate, when a statistical test is done, the observed difference is not found statistically significant. This applies also to the other bars shown in the graph. Yet, the results suggest a lower impact of cyclones on the sales of highly trade-technology-oriented firms, which is econometrically verified when an index of trade-technology orientation is used (see table 3).

Appendix A9. Differential effect of cyclones on Indian manufacturing firms according to the intensity of cyclones

The losses suffered by manufacturing plants because of cyclones are expected to increase with the cyclones' intensity. To study this aspect, the cyclone dummy variable used in the analysis in section 6 has been replaced by two dummy variables, making a distinction between: (a) cyclonic storms (wind speed 62–87 km/h) and severe cyclonic storms (wind speed 88–117 km/h), and (b) very severe cyclones (wind speed 118–167 km/h) and extremely severe cyclones (wind speed 168–221 km/h) (see appendix A1).[3] These two dummy variables are hereafter denoted by C^S and C^{VS}, respectively. The dummy variable C^S takes the value of one for a particular firm for a particular year if the firm had a plant in a district that was affected by a cyclonic storm or a severe cyclonic storm in that year, zero otherwise. Similarly, the dummy variable C^{VS} represents very severe and extremely severe cyclones.

Equation (3) explaining real sales (see section 4.2.2) has been estimated using the abovementioned two dummy variables representing cyclones instead of one dummy variable for cyclones, making a distinction according to wind speed as explained above. The model also includes a dummy variable representing participation in R&D activities or involvement in technology imports or both (lagged by one year). The results are presented in table A8.

A similar change in specification has been made to estimate equation (5), which explains the change in capital stock (see section 4.2.2). The estimated model includes the two dummy variables mentioned above that represent cyclones of different intensities. The results are presented in table A9.

[3] There was no super cyclone (wind speed more than 222 km/h) during the period under study.

Table A8. Regression results, explaining real sales, fixed-effects model, incorporating the intensity of cyclones

Dependent variable: logarithm of real sales

Explanatory variables	Firms with a single plant Reg-A14	Firms with 1–3 plants in the same state Reg-A15
C^{VS}	–0.054	–0.056
	(0.026)	(0.016)
C^{S}	–0.059	–0.044
	(0.038)	(0.016)
OFDI intensity	2.403	2.756
	(1.157)	(0.863)
$\ln(LP)_{t-1}$	0.388	0.384
	(0.020)	(0.020)
ln(Age)	1.047	1.061
	(0.101)	(0.117)
XI_{t-1}	0.184	0.166
	(0.050)	(0.038)
$RDTI_{t-1}$	0.155	0.140
	(0.019)	(0.016)
Joint test of the above seven coefficients (null hypothesis, all equal to zero); F-ratio and prob.	87.0 (0.000)	155.0 (0.000)
R-squared, within	0.25	0.25
R-squared, overall	0.07	0.08
No. of observations	32,859	37,537
No. of firms	4,159	4,674

Notes: Robust standard errors clustered at the district level in Reg-A14 and the state level in Reg-A15, shown in parentheses. The regressions include state-by-year dummies.
Variable notation: C^{S} = Cyclone dummy-I (cyclonic storms and severe cyclones); C^{VS} = Cyclone dummy-II (very severe and extremely severe cyclones); LP= labour productivity (one year lagged); XI= export intensity (one year lagged); RDTI = dummy for firms engaged in R&D or technology imports or both, dummy variable (one year lagged).
Source: Authors' computations based on the Prowess database.

Table A9. Estimates of the model explaining real capital stock, first-differenced instrument variable (FD_IV) regression, incorporating the intensity of cyclones

Dependent variable: logarithm of the real value of total assets (first-differenced)

Explanatory variables	Firms with a single plant Reg-A16	Firms with 1–3 plants Reg-A17
ΔlnK_{t-1}	0.407 (0.026)	0.399 (0.025)
ΔCyclone dummy (C^{VS})	–0.015 [Cof-1] (0.009)	–0.016[Cof-1] (0.005)
Δ $[C^{VS}]_{t-1}$	–0.026[Cof-2] (0.009)	–0.028[Cof-2] (0.008)
ΔCyclone dummy (C^{S})	–0.016[Cof-3] (0.012)	–0.016[Cof-3] (0.005)
Δ $[C^{S}]_{t-1}$	–0.0005[Cof-4] (0.009)	–0.003[Cof-4] (0.005)
ΔDE	–0.0027 (0.0005)	–0.0027 (0.0004)
ΔDE_{t-1}	–0.0022 (0.0005)	–0.0018 (0.0004)
ΔPR	0.110 (0.011)	0.120 (0.011)
ΔPR_{t-1}	0.049 (0.013)	0.048 (0.011)
Δlnklr	–0.078 (0.009)	–0.074 (0.008)
$\Delta lnklr_{t-1}$	–0.002 (0.003)	–0.004 (0.003)
Constant	0.032 (0.002)	0.035 (0.002)
No. of observations	19,352	27,318
No. of firms	3,377	4,549
R-squared (overall)	0.97	0.98
Wald chi-square, and prob.	380.6 (0.000)	569.1 (0.000)

Notes: Robust standard errors, clustered at the district level in Reg-A16 and the firm level in Reg-A17, are shown in parentheses. Observations in which Δ*lnK* is more than 2 or less than (-2) have been dropped.
Variable notation: lnK = log of the real value of total assets; C^{S} = Cyclone dummy-I (cyclonic storms and severe cyclones); C^{VS} = Cyclone dummy-II (very severe and extremely severe cyclones); DE = Debt-equity ratio (lagged); PR = Profit (PBDITA) by sales; *lnklr* = Capital-labour ratio (in logarithms, one year lagged).
Source: Authors' computations based on the Prowess database.

In the estimated model explaining real sales of firms with 1–3 plants in the same state, the numerical value of the coefficient for C^S is lower than that for C^{VS}; both coefficients are statistically significant (table A8). In the case of single-plant firms, the coefficient for C^S is statistically insignificant, whereas the coefficient for C^{VS} is statistically significant. It may thus be inferred that the adverse impact of very severe and extremely severe cyclones on the real sales of manufacturing firms is more substantial than the impact of cyclonic storms and severe cyclones. Thus, the loss in sales of manufacturing firms due to cyclones increases with the cyclones' intensity.

In the model estimated to explain the real value of total assets, the lagged difference term for C^{VS} is statistically significant, and that for C^S is statistically insignificant (table A9). The results for the current difference term for C^S and C^{VS} are mixed – statistically significant in some cases, and statistically insignificant in other cases. Adding the coefficients of the current and the lagged difference terms, the sum (absolute value) is bigger for C^{VS} than that for C^S, i.e., (Cof-1+Cof-2) is significantly larger than (Cof-3+Cof-4). These results indicate that the adverse effect of very severe and extremely severe cyclones on the capital stock of manufacturing firms is more pronounced than the effect of cyclonic storms and severe cyclones.

Appendix A10. Regression results using a measure of firm exposure to wind

The regression results in section 6 used a dummy variable to represent the impact of cyclones. To confirm the findings, an alternative approach has been taken by using firm exposure to high-speed winds as an explanatory variable. The results are shown in tables A10 and A11. The results are discussed in section 7 of the paper.

Table A10. Regression results, explaining real sales, fixed-effects model, firms with a single plant, based on firm exposure to high-speed winds

Dependent variable: logarithm of real sales

Explanatory variables	Reg-A18	Reg-A19
	Firms with a single plant	Firms with a single plant, except those with high trade-technology orientation
Firm exposure to high-speed wind (X)	–0.275 [Cof-1] (0.142)	–0.197 (0.095)
Dummy variable for high trade-technology orientation (HTTO) multiplied by (X)	0.177 [Cof-2] (0.197)	
OFDI intensity	2.802 (1.235)	3.386 (1.774)
Logarithm of lagged labour productivity	0.394 (0.021)	0.381 (0.021)
Logarithm of age	1.027 (0.102)	1.091 (0.116)
Lagged export intensity	0.192 (0.053)	0.243 (0.075)
Joint test of the above five/six coefficients; F-ratio and prob.	86.0 (0.000)	94.4 (0.000)
R-squared, within	0.24	0.23
R-squared, overall	0.07	0.05
No. of firms	3,864	3.455
No. of observations	31,112	22,046

Notes: Robust standard errors clustered at the district level shown in parentheses. State-by-year dummy variables are included. The sum of Cof-1 and Cof-2 is statistically insignificant. The test statistics (F-value) is 0.3, with a probability of 0.57.
Source: Authors’ computations based on the Prowess database.

Table A11. Estimates of the model explaining real capital stock, first-differenced instrument variable (FD_IV) regression, based on firm exposure to high-speed winds

Dependent variable: logarithm of the real value of total assets (first-differenced)

Explanatory variables	Firms with a single plant Reg-A20	Firms with a single plant, except those with high trade-technology orientation Reg-A21
ΔlnK_{t-1}	0.397	0.424
	(0.028)	(0.039)
Δ exposure to high-speed wind (X)	–0.096	–0.084
	(0.050)	(0.048)
ΔX_{t-1}	–0.085	–0.084
	(0.045)	(0.040)
HTTO *ΔX	0.132	
	(0.059)	
$(HTTO *\Delta X)_{t-1}$	0.144	
	(0.053)	
ΔDE	–0.0027	–0.0032
	(0.0005)	(0.0007)
ΔDE_{t-1}	–0.0019	–0.0023
	(0.0005)	(0.0006)
ΔPR	0.102	0.123
	(0.012)	(0.012)
ΔPR_{t-1}	0.049	0.042
	(0.013)	(0.012)
Δlnklr	–0.078	–0.075
	(0.009)	(0.012)
$\Delta lnklr_{t-1}$	–0.002	0.001
	(0.003)	(0.004)
Constant	0.033	0.027
	(0.002)	(0.003)
No. of observations	18,833	11,800
No. of firms	3,154	2,612
R-squared (overall)	0.97	0.97
Wald chi-square, and prob.	731.5	543.1
	(0.000)	(0.000)

Notes: Robust standard errors clustered at the district level are shown in parentheses. Observations in which Δ*lnK* is more than 2 or less than (–2) have been dropped.
Variable notation: lnK = log of the real value of total assets; DE = Debt-equity ratio (lagged); PR = Profit (PBDITA) by sales; *lnklr* = Capital-labour ratio (in logarithms, one year lagged). HTTO = Dummy variable for high trade-technology orientation.
Source: Authors’ computations based on the Prowess database.

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