Table S1. Global Moran's I statistics for industrial robot exposure and urban LCTE, 2010–2023

Year	Variable	Moran's I	Z-value	Variable	Moran's I	Z-value
2010	Robot	0.0101	0.4618	LCTE	0.0992**	2.5426
2011	Robot	0.0217*	1.6927	LCTE	0.0814**	2.0882
2012	Robot	0.0226*	1.7133	LCTE	0.1284***	3.2434
2013	Robot	0.0434**	2.1749	LCTE	0.1433***	3.6140
2014	Robot	0.1010***	3.2971	LCTE	0.0704*	1.8192
2015	Robot	0.2703***	6.6999	LCTE	0.0611	1.5805
2016	Robot	0.1610***	4.3998	LCTE	0.0963**	2.4578
2017	Robot	0.1987***	5.0223	LCTE	0.1506***	3.8044
2018	Robot	0.2692***	6.6723	LCTE	0.0834**	2.1260
2019	Robot	0.2692***	6.6721	LCTE	0.1398***	3.5013
2020	Robot	0.2689***	6.6655	LCTE	0.1657***	4.1364
2021	Robot	0.2945***	7.2987	LCTE	0.1219***	3.1012
2022	Robot	0.2701***	6.6937	LCTE	0.1072**	2.7038
2023	Robot	0.2687***	6.6610	LCTE	0.0967**	2.4739

Note: *The baseline spatial weight matrix is a row-standardized first-order geographical contiguity matrix. Six cities without contiguous neighbours are retained as zero-weight rows. Z-values are analytic under the randomization assumption; significance levels are based on 999-permutation p-values adjusted with the Benjamini–Hochberg procedure within each variable. *** q < 0.01, ** q < 0.05, * q < 0.10.*

Table S2. Robustness of the benchmark estimates to a CRS-based Super-SBM measure of LCTE

Variables	(1) Baseline VRS	(2) Robustness CRS
Robot	0.0106***	0.0026*
	(0.0028)	(0.0015)
Constant	0.7536***	0.5570***
	(0.0420)	(0.0322)
Observations	3,892	3,892
R^2	0.6753	0.6720
Controls	Yes	Yes
City FE	Yes	Yes
Year FE	Yes	Yes
City-clustered SE	Yes	Yes

Note: *City-clustered standard errors are reported in parentheses. The reported R^2 is the overall coefficient of determination from the two-way fixed-effects model. *** p<0.01, ** p<0.05, * p<0.1.*

Table S3. Sensitivity of the benchmark estimates to exposure timing and the exclusion of administrative-center cities

Variables	(1)	(2)	(3)	(4)
Robot	0.0106***		0.0114***	
	(0.0028)		(0.0029)	
L.Robot		0.0071***		0.0077***
		(0.0023)		(0.0023)
Constant	0.7536***	0.7290***	0.7289***	0.6952***
	(0.0420)	(0.0458)	(0.0443)	(0.0492)
Observations	3,892	3,614	3,472	3,224
R^2	0.6753	0.6832	0.6521	0.6589
Controls	Yes	Yes	Yes	Yes
City FE	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes
City-clustered SE	Yes	Yes	Yes	Yes

Note: *City-clustered standard errors are reported in parentheses. The reported R^2 is the overall coefficient of determination from the two-way fixed-effects model. *** p<0.01, ** p<0.05, * p<0.1. Columns (1): Baseline; Columns (2): Lagged exposure; (3): Exclude administrative centers; (4): Lagged; exclude centers.*

Table S4. Full Spatial Durbin model estimates under the baseline geographical contiguity matrix

Variable	(1) Local coefficient	(2) Spatial-lag coefficient
Robot	0.0113	-0.0042
OIM SE	(0.0009) ***	(0.0015) ***
City-clustered SE	(0.0030) ***	(0.0028)
Ln_popden	-0.0104	0.0174
OIM SE	(0.0073)	(0.0090) *
City-clustered SE	(0.0068)	(0.0083) **
Urban	0.0080	-0.0354
OIM SE	(0.0382)	(0.0675)
City-clustered SE	(0.0424)	(0.0802)
Open	0.0397	-0.0559
OIM SE	(0.0180) **	(0.0241) **
City-clustered SE	(0.0188) **	(0.0233) **
Industry	0.0040	-0.0114
OIM SE	(0.0075)	(0.0105)
City-clustered SE	(0.0075)	(0.0102)
Hc	-0.5425	0.3132
OIM SE	(0.2437) **	(0.3509)
City-clustered SE	(0.2588) **	(0.3290)
Fis	-0.6334	-0.0806
OIM SE	(0.0519) ***	(0.0859)
City-clustered SE	(0.0792) ***	(0.1196)
Spatial autoregressive coefficient (rho)	0.1295	
OIM SE	(0.0227) ***	
City-clustered SE	(0.0266) ***	
Observations	3,892	
Cities	278	
City fixed effects	Yes	
Year fixed effects	Yes	
Log likelihood	663.073	
Pseudo-R^2	0.0103	
SDM vs. SAR: Wald statistic (OIM / clustered)	17.902/13.999	
SDM vs. SAR: p-value (OIM / clustered)	0.0124/0.0512	
SDM vs. SEM: Wald statistic (OIM / clustered)	16.062/14.043	
SDM vs. SEM: p-value (OIM / clustered)	0.0246/0.0504	

Note: *Observed-information-matrix (OIM) standard errors from spxtregress are reported in the rows labelled "OIM SE", and stand-ard errors clustered at the city level (278 clusters), obtained with xsmle, in the rows labelled "City-clustered SE"; stars indicate significance under the corresponding standard errors. Coefficient estimates are identical under the two procedures. The model includes the spatial lag of LCTE, industrial robot exposure, all control variables and their corresponding spatial lags, together with city fixed effects and year dummies; the year dummies are not spatially lagged. The baseline spatial weight matrix is a row-standardized first-order geographical contiguity matrix. The log likelihood and pseudo-R^2 are those reported by spxtregress;*

*the pseudo-R^2 is specific to the spatial estimator. Direct, indirect and total effects of industrial robot exposure are reported in Table 8. *** p < 0.01, ** p < 0.05, * p < 0.10.*

Table S5. Continuous city-size heterogeneity in the association between industrial robot exposure and urban LCTE

Variables	(1) Baseline	(2) Continuous interaction
Robot	0.0106***	0.0102***
	(0.0028)	(0.0028)
Ln_respop (centered)		0.1539*
		(0.0865)
Robot × Ln_respop (centered)		-0.0040***
		(0.0015)
Constant	0.7536***	0.7429***
	(0.0420)	(0.0396)
Observations	3,892	3,892
R^2	0.6753	0.6789
Controls	Yes	Yes
City FE	Yes	Yes
Year FE	Yes	Yes
City-clustered SE	Yes	Yes
Interaction p-value		0.00613

Note: *Column (1) reports the baseline two-way fixed-effects estimate. Column (2) adds the mean-centered natural logarithm of resident population (Ln_respop, resident population in units of 10,000 persons) and its interaction with industrial robot exposure. The coefficient on Robot in column (2) therefore represents the association with LCTE at the sample mean of log resident population. The interaction coefficient has a p-value of 0.006. All specifications include the full set of control variables and city and year fixed effects. City-clustered standard errors are reported in parentheses. R^2 denotes the overall coefficient of determination. *** p < 0.01, ** p < 0.05, * p < 0.10.*

Table S6. Comparison with related city-level spatial studies

Study	Technological variable	Outcome	Sample	Reported local estimate	Reported cross-city estimate	Reported total effect	Estimate type
[41] Dai et al.	AI Application	Urban GTFP	279 cities, 2012–2021	0.0002	0.0017	NR	Local and spatial-lag coefficients
				0.0095	0.0015	0.0110	
[69] Wang et al.	AI development	Energy efficiency	278 cities				Direct, indirect and total effects
Present study	Industrial robot exposure	Urban LCTE	278 cities, 2010–2023	0.0113	-0.0029	0.0083	Direct, indirect and total effects

Note: *NR, not reported. The estimates are not directly comparable in magnitude because the studies differ in technological constructs, outcome measures, variable scales, spatial weight matrices and reported spatial statistics. Dai et al. report model coefficients, whereas Wang et al. and the present study report decomposed spatial effects.*

Table S7. Lagrange multiplier tests based on the residuals of the non-spatial two-way fixed-effects model

Spatial weight matrix	LM-lag	p-value	Robust LM-lag	p-value	LM-error	p-value	Robust LM-error	p-value
Contiguity	37.977	<0.001	40.089	<0.001	0.017	0.8972	2.128	0.1446
Economic–geographical nested	0.061	0.8046	0.154	0.6944	0.335	0.5625	0.429	0.5127
Economic–geographical weight	6.002	0.0143	8.199	0.0042	2.125	0.1449	4.322	0.0376
Inverse distance, 150 km	34.508	<0.001	39.599	<0.001	1.106	0.2930	6.198	0.0128
Inverse distance, 300 km	62.425	<0.001	68.650	<0.001	0.003	0.9570	6.228	0.0126
Inverse distance, 500 km	45.949	<0.001	52.188	<0.001	0.025	0.8744	6.264	0.0123

Note: The tests use the residuals of the two-way fixed-effects model of LCTE on industrial robot exposure and the control variables after removing city and year means. All matrices are row-standardized; cities without neighbours are retained as zero-weight rows. p-values are based on the $\chi^2(1)$ distribution.

Table S8. Spatial Durbin model estimates under inverse-distance matrices with alternative distance bands

Matrix	Rho	Local coefficient	Spatial-lag coefficient	Direct effect	Indirect effect	Total effect
150 km	0.1145	0.0111	-0.0026	0.0111	-0.0013	0.0098
OIM SE	(0.0204) ***	(0.0009) ***	(0.0012) **	(0.0009) ***	(0.0012)	(0.0014) ***
City-clustered SE	(0.0255) ***	(0.0030) ***	(0.0025)	(0.0031) ***	(0.0025)	(0.0033) ***
300 km	0.2267	0.0113	-0.0067	0.0112	-0.0052	0.0061
OIM SE	(0.0322) ***	(0.0009) ***	(0.0019) ***	(0.0009) ***	(0.0023) **	(0.0024) **
City-clustered SE	(0.0371) ***	(0.0029) ***	(0.0039) *	(0.0030) ***	(0.0048)	(0.0051)
500 km	0.2641	0.0117	-0.0107	0.0116	-0.0102	0.0014
OIM SE	(0.0445) ***	(0.0009) ***	(0.0027) ***	(0.0009) ***	(0.0035) ***	(0.0034)
City-clustered SE	(0.0468) ***	(0.0030) ***	(0.0056) *	(0.0030) ***	(0.0074)	(0.0071)

*Note: Each model includes city fixed effects, year dummies, all control variables and their spatial lags; year dummies are not spatially lagged. Each model uses 3,892 observations from 278 cities. Matrices are row-standardized inverse-distance matrices truncated at 150, 300 and 500 km; cities without neighbours within the band (20 at 150 km and 3 at 300 km) are retained as zero-weight rows. Observed-information-matrix (OIM) standard errors from spxtregress are reported in the rows labelled "OIM SE", and stand-ard errors clustered at the city level (278 clusters), obtained with xsmle, in the rows labelled "City-clustered SE"; stars indicate significance under the corresponding standard errors. Effect estimates are delta-method estimates from spxtregress; components may not sum exactly because of rounding. *** p < 0.01, ** p < 0.05, * p < 0.10.*

Table S9. Sensitivity of the benchmark estimate to the exclusion of provinces with acknowledged statistical misreporting

Variables	(1) Full sample	(2) Excl. TJ, IM, LN	(3) Also excl. JL	(4) Excl. TJ, IM, LN, 2011–2017
Robot	0.0106***	0.0108***	0.0107***	0.0106***
	(0.0028)	(0.0029)	(0.0030)	(0.0029)
Constant	0.7536***	0.7449***	0.7356***	0.7461***
	(0.0420)	(0.0444)	(0.0449)	(0.0436)
Observations	3,892	3,556	3,444	3,724
Cities	278	254	246	278
Overall R^2	0.6753	0.6773	0.6779	0.6783
Within R^2	0.0826	0.0829	0.0775	0.0821
Controls	Yes	Yes	Yes	Yes
City FE	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes
City-clustered SE	Yes	Yes	Yes	Yes

*Note: TJ = Tianjin; IM = Inner Mongolia; LN = Liaoning; JL = Jilin. Column (4) excludes observations from Tianjin, Inner Mongolia and Liaoning for 2011–2017 only. City-clustered standard errors are reported in parentheses. R^2 is the overall coefficient of determination; Within R^2 excludes the variation explained by the city and year fixed effects. *** p < 0.01, ** p < 0.05, * p < 0.1.*

Table S10. Coefficient-stability analysis [69]

Variables	(1) Without controls	(2) With controls
Robot	0.0106	0.0106
Within R^2	0.037	0.083
Observations	3,892	3,892
Controls	No	Yes
City FE	Yes	Yes
Year FE	Yes	Yes
Bound estimates	$R_{max} = 1.3 \times R^2$	$R_{max} = 1$
δ required for $\beta = 0$	289.33	18.77
Bias-adjusted β^* ($\delta = 1$)	0.0107	0.0113

Note: Variables are demeaned by city and year before estimation, and R^2 denotes the within R^2. Column (1) corresponds to Table 3, column (1), and column (2) to Table 3, column (2). δ is the degree of selection on unobservables, relative to selection on observables, that would be required to reduce the Robot coefficient to zero; β^* is the bias-adjusted coefficient assuming equal selection ($\delta = 1$). R_{max} is the hypothetical R^2 from a regression including all observed and unobserved controls. Estimates were obtained with psacalc in Stata.

Table S11. Direction of feedback between LCTE and industrial robot exposure

Variables	(1) Robot_t	(2) LCTE_t	(3) LCTE_t	(4) LCTE_t
LCTE_{t−1}	-1.3310**			0.4023***
	(0.6375)			(0.0408)
Robot_{t−1}	0.8005***			0.0026
	(0.0675)			(0.0019)
Robot_t		0.0187***	0.0114***	
		(0.0049)	(0.0034)	
Robot_{t+1}		-0.0092**		
		(0.0044)		
Constant	0.8443	0.8074***	0.7695***	0.4810***
	(0.8439)	(0.0393)	(0.0409)	(0.0511)
Observations	3,614	3,614	3,614	3,614
Overall R^2	0.9159	0.6861	0.6821	0.7376
Within R^2	0.5820	0.0948	0.0833	0.2213
Controls	Yes	Yes	Yes	Yes
City FE	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes

City-clustered SE	Yes	Yes	Yes	Yes

*Note: Column (1) regresses robot exposure on lagged LCTE; column (2) adds one-year-ahead robot exposure to the LCTE equation; column (3) re-estimates the benchmark model on the same sample as column (2) (2010–2022); column (4) regresses LCTE on lagged robot exposure while controlling for lagged LCTE. Columns (1) and (4) include a lagged dependent variable and may be subject to Nickell bias; column (2) contains no lagged dependent variable. City-clustered standard errors are reported in parentheses. R^2 is the overall coefficient of determination; Within R^2 excludes the variation explained by the city and year fixed effects. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.*

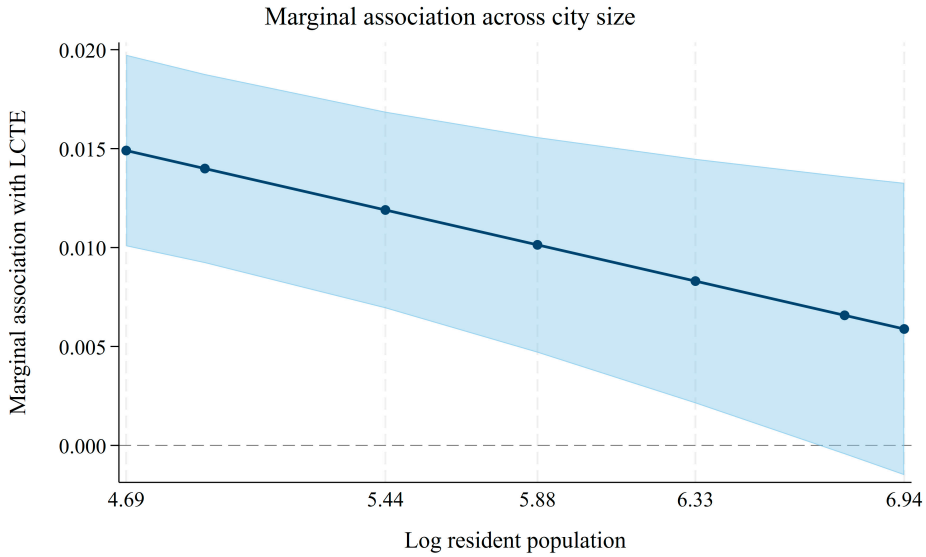


Figure S1. Marginal association between industrial robot exposure and LCTE across resident population size

Figure S1 Note: *The solid line shows the estimated marginal association of industrial robot exposure with LCTE across the observed distribution of log resident population. The shaded area denotes the 95% confidence interval. Estimates are derived from a two-way fixed-effects model with city-clustered standard errors.*