

Boosted income, busted environment: a tradeoff in the wider economic impacts of transport corridor investments?

Martin Melecký^{1,2}, Siddharth Sharma^{1*}, and Hari Subhash³

¹The World Bank, Washington, DC, USA, ²VSB-Technical University of Ostrava, Czech Republic and ³Kinetica, Washington, DC, USA

*Corresponding author. E-mail: ssharma1@worldbank.org

ONLINE APPENDIX

Table A1. Summary of outcome variables in 2001 and 2011

Outcome variable	Source code*	Outcome type	No. of obs.	25th percentile	Median value	75th percentile	Mean value	Standard deviation
Year 2001								
Log GDP per capita	E	Welfare	427	5.35	5.72	6.06	5.66	0.56
Aerosol optical thickness	B	Environment	427	0.26	0.32	0.47	0.36	0.13
Nitrogen dioxide level	B	Environment	427	131.00	159.00	193.50	165.49	52.70
Non-farm Employed - total	D	Structure	427	24.90	33.60	49.13	39.18	19.56
Farm employed - total	D	Structure	427	50.85	66.40	75.00	60.74	19.60
Employment rate	D	Structure	427	41.10	48.60	53.40	47.86	7.79
Year 2011								
Outcome variable	Source code	Outcome type	No. of obs.	25th percentile	Median value	75th percentile	Mean value	Standard deviation
Log GDP per capita	E	Welfare	427	5.61	6.02	6.39	5.93	0.64
Aerosol optical thickness	B	Environment	427	0.31	0.38	0.56	0.43	0.16
Nitrogen dioxide level	B	Environment	427	144.00	176.00	216.00	185.76	62.95
Non-farm employed - total	D	Structure	427	28.00	36.90	52.30	42.41	20.01
Farm employed - total	D	Structure	427	47.60	63.10	72.00	57.53	19.98
Employment rate	D	Structure	427	40.70	47.20	53.40	47.24	7.51

Note: obs. = observations. *: Source code key provided in table A3.

Table A2. Summary of initial condition variables

Initial conditions in local markets	Source code*	No. of obs.	25th percentile	Median value	75th percentile	Mean value	Standard deviation
Educ: Secondary education completion rate, 15+ years (per cent of population group)	I	854	17.00	22.8	28.95	23.20	8.46
Cropland: Cropland as per cent of area	A	854	29.05	60.1	88.30	56.79	32.25

Notes: ISIC = International Standard Industrial Classification; obs. = observations. *: Source code key provided in table A3.

Table A3. List of data source codes

Source code	Name
A	MODIS Land Cover Type I product (MODIS). Information and images obtained from National Aeronautics and Space Administration (NASA) Land Processes Distributed Active Archive Center (LP DAAC), USGS/Earth Resources Observation and Science (EROS) Center, Sioux Falls, South Dakota, https://lpdaac.usgs.gov/data_access .
B	National Aeronautics and Space Administration (NASA) Earth Observations (NEO-ND). URL: for NO2 and for Aerosol Optical Thickness .
D	Census of India–Primary Census Abstract (PHC–PCA), Office of the Registrar General and Census Commissioner, Government of India, http://censusindia.gov.in .
E	State-wise Gross District Domestic Product (DDP), Directorate of Economics and Statistics, Planning Commission, Government of India, http://planningcommission.nic.in/plans/stateplan/index.php?state=ssphdbody.htm .
I	The Household Consumption Expenditure Survey of National Sample Survey (NSS–HCE), National Sample Survey Office (NSSO), the Ministry of Statistics and Programme Implementation, Government of India, http://mospi.nic.in/Mospi_New/site/inner.aspx?status=2&menu_id=71 .

Table A4. District distribution by distance to the highway

a. By all distance bands, with nodal districts included

		NSEW				Total
		Nodal	0–40 km	40–100 km	> 100 km	(excluding nodal)
GQ	Nodal	4	0	0	4	
	0–40 km	1	2	10	60	72
	40–100 km	0	6	10	60	76
	> 100 km	1	32	43	194	269
	Total (excluding nodal)		40	63	314	417

Notes: GQ = Golden Quadrilateral; NSEW = North-South-East-West Highway. The table shows the number of districts in each distance band cell.

Table A5. District distribution by actual distance versus straight line distance to GQ Highway (nodal districts excluded)

a. GQ

		Distance to Actual GQ		
		0–40 km	> 40 km	Total
Distance to GQ	0–40 km	35	30	65
Straight Line Version	> 40 km	37	315	352
	Total	72	345	417

Note: The table shows the number of districts in each distance band cell.

b. NSEW

		Distance to Actual NSEW		
		0–40 km	> 40 km	Total
Distance to NSEW	0–40 km	25	19	44
Straight Line Version	> 40 km	15	358	373
	Total	40	377	417

Notes: GQ = Golden Quadrilateral; NSEW = North-South-East-West Highway. The table shows the number of districts in each distance band cell.

Table A6. Estimated impacts on GQ's downwind districts

Variables	(1) Log GDPpc	(2) AOT	(4) Nitrogen dioxide
PostGQ*GQ (0–40)	0.0401 (0.0199)	0.0261 (0.0074)	0.9680 (2.6016)
PostGQ* Downwind Districts	0.0131 (0.0348)	0.0289 (0.0093)	-0.0288 (3.3546)
PostGQ* Near GQ	0.0143 (0.0254)	0.0175 (0.0094)	2.9241 (2.9259)
PostNSEW*NSEW (0–40)	0.0041 (0.0234)	0.0103 (0.0100)	-1.7351 (2.2350)
State*Year and District FEs	Yes	Yes	Yes
Observations	854	854	854
R-squared	0.9936	0.9936	0.9844

Notes: OLS estimates. Standard errors are clustered at the district-level. Downwind is defined as a district that is within 100 km of a GQ adjoining district and whose centroid's direction from the GQ district is within 45 degrees of the GQ district's wind direction. Wind direction is derived using the u and v components of the wind direction and averaging over 2000 and 2001.

Table A7. 2SLS-IV: First-stage results

Variables	(1) PostGQ*GQ(0-40)	(2) PostNSEW*NSEW(0-40)
PostGQ*GQ Straight (0–40)	0.3777 (0.0957)	-0.0338 (0.0381)
PostNSEW*NSEW Straight (0–40)	0.0035 (0.0957)	0.4374 (0.1111)
State*Year and District FEs	Yes	Yes
Observations	854	854
R-squared	0.6552	0.6990

Notes: The ordinary least squares (OLS) estimation includes PostGQ, PostNSEW and their interactions with dummies for nodal districts as controls. Standard errors clustered by district in parentheses.

Table A8. Impacts of highways on income and environmental quality (2SLS-IV estimates)

Variables	(1) Log GDP per capita	(2) Aerosol optical thickness	(3) NOx levels
PostGQ*GQ (0–40)	0.0278 (0.0356)	0.0387 (0.0136)	2.5055 (4.7708)
PostNSEW*NSEW (0–40)	-0.0344 (0.0322)	0.0202 (0.0161)	-5.8597 (3.8042)
State*Year and District FEs	Yes	Yes	Yes
Observations	854	854	854
R-squared	0.9935	0.9830	0.9892

Notes: PostGQ*GQ(0-40) and PostNSEW*NSEW(0-40) instrumented by their corresponding straight line distance band interactions. Interactions of PostGQ and PostNSEW with nodal district dummies included as controls. Standard errors clustered by district in parentheses.

Table A9. Heterogenous impacts of highways (2SLS-IV estimates)

Variables	(1) Log GDP per capita	(2) Aerosol optical thickness	(3) NOx levels	(4) Log GDP per capita	(5) Aerosol optical thickness	(6) NOx levels
PostGQ*GQ (0–40)	0.0072 (0.0379)	0.0579 (0.0143)	-5.0927 (4.8747)	0.0565 (0.0341)	-0.0061 (0.0105)	0.9022 (3.8360)
PostGQ*GQ (0–40)*Educ	0.0010 (0.0015)	-0.0018 (0.0006)	0.2036 (0.1871)			
PostNSEW*NSEW(0–40)	-0.0253 (0.0372)	0.0308 (0.0200)	4.7967 (4.4034)	-0.0404 (0.0384)	-0.0400 (0.0128)	-2.7619 (3.3378)
PostNSEW*NSEW (0–40)*Educ	0.0011 (0.0015)	-0.0010 (0.0008)	-0.3047 (0.2039)			
PostGQ*GQ (0–40)*Cropland				-0.0003 (0.0005)	0.0004 (0.0002)	-0.0080 (0.0559)
PostNSEW*NSEW (0–40)*Cropland				0.0007 (0.0006)	0.0007 (0.0002)	0.0030 (0.0593)
State*Year and District FEs	Yes	Yes	Yes	Yes	Yes	Yes
Observations	854	854	854	854	854	854
R-squared	0.9936	0.9839	0.9895	0.9936	0.9843	0.9893

Notes: PostGQ*GQ(0-40) and PostNSEW*NSEW(0-40) instrumented by their corresponding straight line distance band interactions. Interactions of PostGQ and PostNSEW with nodal district dummies included as controls. Standard errors clustered by district in parentheses.

Table A10. Impacts of highways on farm and non-farm employment (2SLS-IV estimates)

Variables	(1) Non-farm Employment	(2) Non-farm Employment	(3) Non-farm Employment
PostGQ*GQ (0–40)	1.5783 (0.8811)	-1.9485 (1.8800)	2.7837 (1.3867)
PostGQ*GQ (0–40)*Educ		0.1438 (0.0763)	
PostNSEW*NSEW(0–40)	2.4476 (1.3578)	-0.4178 (2.4284)	6.2493 (2.1451)
PostNSEW*NSEW(0–40)*Educ		0.1155 (0.0925)	
PostGQ*GQ (0–40)*Cropland			-0.0200 (0.0204)
PostNSEW*NSEW(0–40)*Cropland			-0.0589* (0.0312)
State*Year and District FEs	Yes	Yes	Yes
Observations	854	854	854
R-squared	0.9898	0.9899	0.9899

Notes: PostGQ*GQ(0-40) and PostNSEW*NSEW(0-40) instrumented by their corresponding straight line distance band interactions. Interactions of PostGQ and PostNSEW with nodal district dummies included as controls. Standard errors clustered by district in parentheses.

Table A11. Estimated impact of highways on nightlights

Variables	(1) NTL_area OLS	(2) NTL_area IV	(3) NTL_per capita OLS	(4) NTL_per capita IV
PostGQ*GQ (0-40)	3.3273 (1.2913)	0.0387 (0.0136)	-1.5056 (1.4869)	-1.8554 (1.9778)
PostNSEW*NSEW (0-40)	1.9619 (0.9781)	0.0202 (0.0161)	-0.6020 (1.7067)	0.7420 (2.3159)
State-Year and District FEs	Yes	Yes	Yes	Yes
Observations	854	854	854	854
R-squared	0.9936	0.9830	0.9515	0.9512

Notes: Robust standard errors clustered by district in parentheses. The dependent variable in columns (1) and (2) is the ratio of total night lights intensity to area, and that in columns (3) and (4) is the ratio of total night lights intensity to population (in 1000s). The total intensity of nighttime lights refers to the aggregation of the radiance calibrated light intensity values in terms of digital numbers. The source of the nightlights data is DSMP-OLS Radiance Calibrated Nighttime Lights (RCNTL) (http://ngdc.noaa.gov/eog/dmsp/download_radcal.html).

Table A12. Impact on Aerosol Optimal Thickness Terra (Base year: 2001)

Variables	(1) OLS 2005	(2) OLS 2011	(3) IV 2005	(4) IV 2011
Year *GQ (0–40)	0.0158 (0.0066)	0.0221 (0.0089)	0.0152 (0.010 4)	0.0583 (0.0191)
Year *NSEW (0–40)	-0.0049 (0.0058)	-0.0015 (0.0107)	0.0036 (0.007 6)	0.0027 (0.0151)
State*Year and District FEs	Yes	Yes	Yes	Yes
Observations	844	844	844	844
R-squared	0.9904	0.9838	0.0100	-0.1296

Note: Standard errors are clustered at the district-level

Table A13. Impact on log GDP per capita (Base year: 2001)

Variables	(1) 2005 OLS	(2) 2005 IV	(3) 2011 OLS	(4) 2011 IV
postGQ_GQDum1	0.0694 (0.0729)	0.2756 (0.1775)	0.0402 (0.0198)	0.0278 (0.0356)
postNSEW_NSEWDum1	0.0685 (0.1046)	0.1915 (0.1762)	0.0042 (0.0236)	-0.0344 (0.0322)
State*Year and District FEs	Yes	Yes	Yes	Yes
Observations	818	818	854	854
R-squared	0.9871	0.9864	0.9936	0.9935

Notes: Standard errors are clustered at the district-level. Real district-level GDP data from CEIC was used for 2005. The population is extrapolated for years between 2001 and 2011 using a district-level average growth rate for the decade.

Table A14. Nodal districts

State	District	GQ distance	NSEW distance	GQ straight-line distance	NSEW straight-line distance
Gujarat	Porbandar	317.5313	1.886075	405.7717	0
Haryana	Faridabad	0.010304	31.76897	18.71244	1.205224
Haryana	Gurgaon	0.829699	41.30815	13.04913	35.2665
Karnataka	Bangalore	0.220969	0.220968	0	67.73664
Karnataka	Bangalore rural	21.7138	8.152857	16.66858	69.38587
Kerala	Ernakulam	322.5242	88.827	338.6767	0
Maharashtra	Mumbai	3.37185	386.4158	0	405.7835
Maharashtra	Mumbai suburban	2.350186	374.9798	2.743553	391.7226
NCT of Delhi	Central	1.125572	1.739703	3.797182	2.927443
NCT of Delhi	East	4.644253	4.744387	6.357544	8.826364
NCT of Delhi	New Delhi	0.88681	4.325667	0	0
NCT of Delhi	North	6.318545	0.884115	11.2142	5.506637
NCT of Delhi	North East	6.524806	5.371046	12.4347	10.39161
NCT of Delhi	North West	18.12909	6.215507	21.45096	2.096619
NCT of Delhi	South	8.611861	13.71957	6.114379	3.935371
NCT of Delhi	South West	11.10865	23.30152	15.79743	18.6445
NCT of Delhi	West	13.10197	13.69143	15.16745	10.22288
Punjab	Jalandhar	326.8173	10.6747	330.6815	0
Punjab	Kapurthala	347.822	24.04326	351.6391	21.75046
Tamil Nadu	Chennai	0.964845	228.1311	0	221.3636
Tamil Nadu	Kanniyakumari	478.2926	24.44338	517.4671	0
Tamil Nadu	Salem	93.34125	10.74619	144.6043	0
Tamil Nadu	Thiruvallur	21.39638	203.1678	20.25113	188.3025
Uttar Pradesh	Gautam Buddha Nagar	19.5113	37.03685	3.616564	18.94192
Uttar Pradesh	Jhansi	114.0565	39.72296	217.3647	0
West Bengal	Haora	5.959926	940.6368	16.69946	984.182
West Bengal	Jalpaiguri	389.6221	1059.672	421.8346	1020.105
West Bengal	Kolkata	5.347588	970.4988	0	1012.148

Note: GQ = Golden Quadrilateral; NCT = National Capital Territory. NSEW = North-South-East-West Highway.

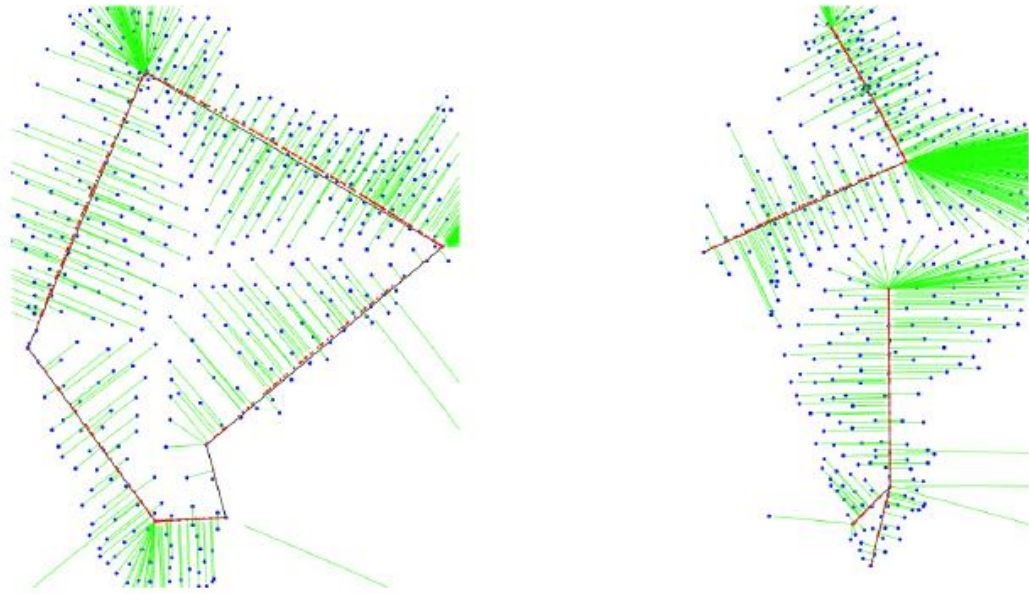


Figure A1. Straight line versions of GQ (left) and NSEW (right) highways networks, with distances from district centroids