The effects of technology intensity in manufacturing on CO_2 emissions: Evidence from developing countries

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Outline

- General background
- Related literature
- Methodology
- Results
- Conclusion
- Policy implications

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Background

- Importance and urgency of the climate problem
  - United Nations Framework Convention on Climate Change (1997),
  - Kyoto protocol (2012)
  - Paris Agreement (2016)
- Industrialisation a contributor to anthropogenic CO_2 emissions *(Appiah et al., 2019; Adom et al., 2012)*

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Background cont.

- Industrialisation key to economic development
  - Development path of Western countries and rapid 'catch-up' of Asian NICs
- Re-emergence of industrialisation as a development agenda in developing economies

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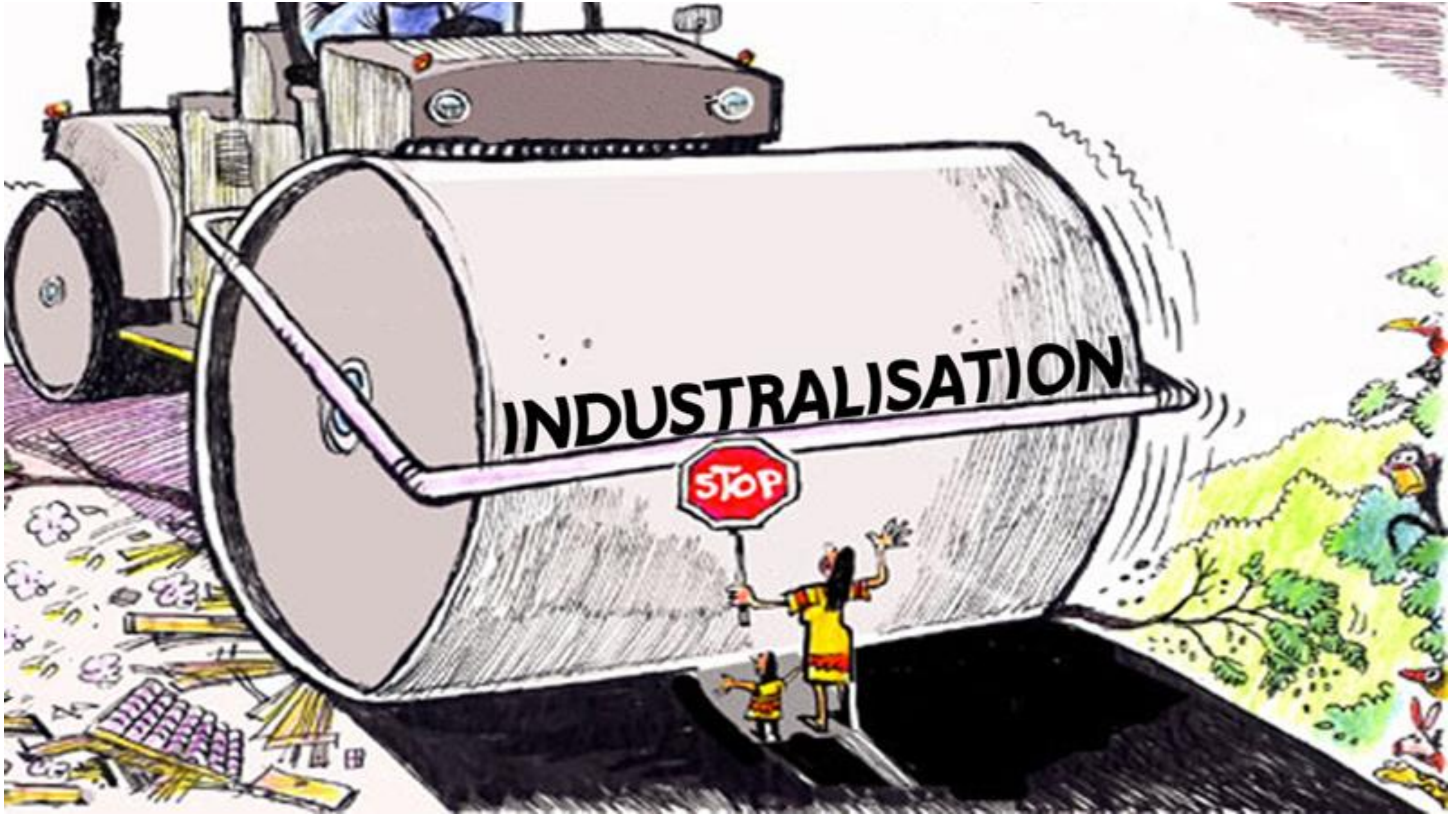
Background cont.



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Background cont.

- Transition to tech-intensive manufacturing best path *(UNIDO, 2016)*
  - ✧Technological frontier industries
  - ✧Enhancement of industrial competitiveness
  - ✧Cleaner production processes

- Dearth of evidence on how mitigating CO_2 emissions may be conditional on technology intensity in manufacturing.

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Related literature

- Often strong opposing views:
  - 'Industrialist': Inverted U-shaped relationship btwn industrialisation on CO_2 emissions
    - Countries can grow and clean up at later stage of dev't *(Padilla, 2017)*
  - Ecological theories *(eg. Robbins, 2017)*
    - Defend environment against the damages of industrial activity through 'de-growth'.
  - Others focus on mitigating the environmental harm caused by industrialisation *(Fischer, 2016; Ashman, Newman, and Tregenna, 2020)*
    - 'green industrial policy' fostering the sustainable production processes
    - de-carbonise industrialisation and grow sustainably through green technological progress (Altenburg & Assmann, 2017; Altenburg & Rodrik, 2017)

Related literature cont.

- Two main empirical approaches:
  - EKC model/hypothesis *(see for example, Friedl and Getzner, 2003)*
    - Inverted-U-shaped relationship between growth and CO_2 emissions *(Liu and Bae, 2018; Xu and Lin, 2015)*
  - Stochastic impact by regression on population, affluence, and technology (STIRPAT) method *(Dietz and Rosa, 1997)*.
    - U-shaped relationship between industrialisation and CO_2 emissions *(de Souza et al., 2018; Balogh and Jambor, 2017; Xu and Lin 2015)*

- We build on Xu and Lin (2015) and augment with a specific focus on MHT manufacturing (and with additional covariates).

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Methodology

- Our basic and extended estimation models are specified as:

$$lnCO_{2it} = \gamma_1 + \gamma_2 lnCO_{2it-1} + \gamma_3 lnGDP_{it} + \gamma_4 lnGDP_{it}^2 + \gamma_5 MAN_{it} + \gamma_6 MAN_{it}^2 + \gamma_7 Z_{it} + \varepsilon_{it} \quad (1)$$

$$lnCO_{2it} = \beta_1 + \beta_2 lnCO_{2it-1} + \beta_3 lnGDP_{it} + \beta_4 lnGDP_{it}^2 + \beta_5 MHT_{it} + \beta_6 MHT_{it}^2 + \beta_9 Z_{it} + \mu_{it} \quad (2)$$

where $lnCO_{2it}$ refers to CO_2 emissions in country *i* in year *t*, $lnCO_{2it-1}$ captures the lag of CO_2 emissions in country *i* in year *t*, both in (ln). MHT_{it} refers to a vector of our MHT indicators of $MHVash\ and\ MHXsh$.

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Data

- 56 developing countries, 1991 – 2014

Variable	Mean	Std. dev.	Min.	Max.	Source
CO_2 emissions (kt)	237 493.5	842 387.2	722.399	1.03e+0	WDI
CO_2 emissions (mt) per capita	2.899	3.358	.017	19.529	WDI
Manufacturing VA	15.294	5.875	1.234	37.508	WDI
Medium- and high-tech VA	21.518	12.619	.248	57.188	UNIDO CIP
Low-tech VA	78.482	12.620	42.812	99.751	UNIDO CIP
High-tech X	8.865	12.895	.0002	74.994	WDI
Medium-tech X	20.207	13.530	.014	81.525	WDI
Low-tech X	70.927	18.969	16.902	98.989	WDI

Data cont.

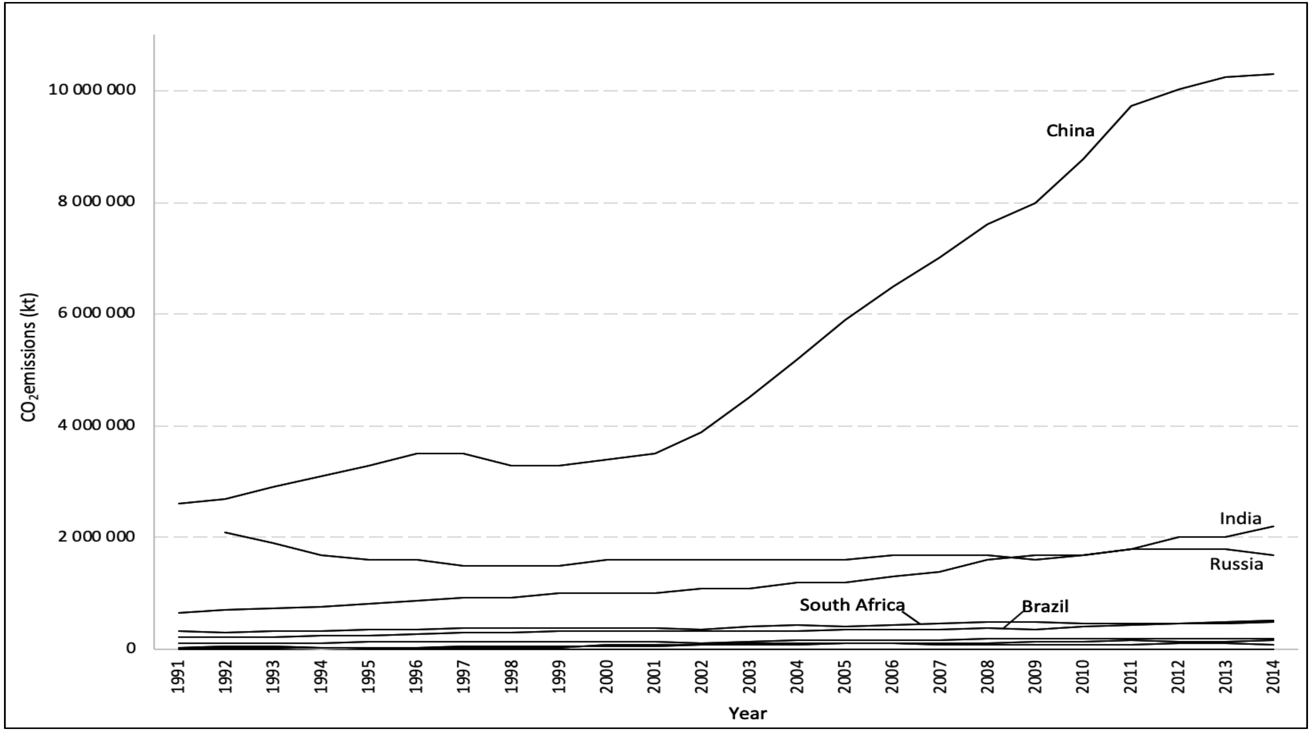

Fig 1a: Evolution of CO_2 emissions (kt) between 1991 and 2014

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Data cont.

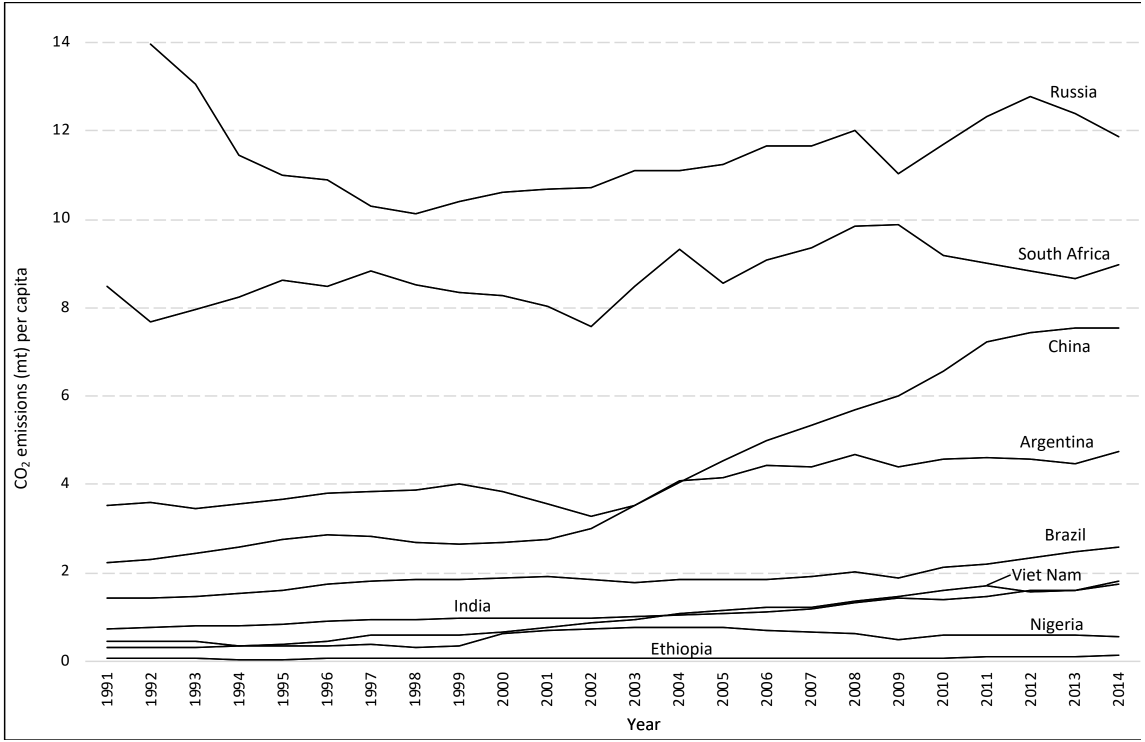

Fig 1b: Evolution of CO_2 emissions (mt) per capita between 1991 and 2014

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Results - Baseline

Two-step GMM estimation	(1)	(2)	(3)	(4)
	CO_2 emissions (kt) (ln)		CO_2 emissions (mt) per capita (ln)	
	Linear	**Quadratic**	**Linear**	**Quadratic**
L. CO_2 emissions (kt) (ln)	0.315^{***}	0.228^{***}		
	(-0.033)	(-0.059)		
L. CO_2 emissions (mt) per capita (ln)			0.235^{***}	0.200^{***}
			(-0.037)	(-0.046)
Manufacturing VA	0.007^{**}	0.029^{***}	0.01	0.017
	(-0.001)	(-0.004)	(-0.002)	(-0.003)
Manufacturing VA square		-0.026^{***}		0.002
		(-8E-05)		(-1E-04)
GDP per capita (ln)	0.000	1.863^{***}	0.227^{**}	1.239^{***}
	(-0.064)	(-1.083)	(-0.152)	(-0.367)
GDP per capita (ln) square		-1.767^{***}		-0.851^{***}
		(-0.060)		(-0.019)

Standardized beta coefficients; Windmeijer bias-corrected robust standard errors in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$; AR test satisfied at level 2. Domestic credit (-); Urbanization (+); Services (-); Renewable energy (-); Fossil fuel (+).

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Results cont.

Two-step GMM estimation	(1)	(2)	(3)	(4)
	CO_2 emissions (kt) (ln)	**CO_2 emissions (mt) per capita (ln)**	**CO_2 emissions (kt) (ln)**	**CO_2 emissions (mt) per capita (ln)**
L. CO_2 emissions (kt) (ln)	0.478^{***}		0.396^{***}	
	(0.009)		(0.0212)	
L. CO_2 emissions (mt) per capita (ln)		0.190^{***}		0.302^{***}
		(0.041)		(0.0219)
Medium- and high-tech VA	-0.059^{***}	-0.062^{**}		
	(0.002)	(0.003)		
Medium- and high-tech VA square	0.034^{***}	0.039^{*}		
	(0.000)	(0.000)		
Low-tech VA			0.268^{***}	0.148^{***}
			(7.02e-15)	(6.61e-15)
Low-tech VA square			-0.187^{**}	-0.248^{**}
			(1.26e-28)	(1.21e-28)

Standardized beta coefficients; Windmeijer bias-corrected robust standard errors in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$; AR test satisfied at level 2. Domestic credit (-); Urbanization (+); Services (-); Renewable energy (-); Fossil fuel (+).

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Results cont.

Two-step GMM	(1)	(2)	(3)	(4)	(5)	(6)
	CO_2 emissions (kt) (ln)	CO_2 emissions (mt) pc (ln)	CO_2 emissions (kt) (ln)	CO_2 emissions (mt) pc (ln)	CO_2 emissions (kt) (ln)	CO_2 emissions (mt) pc (ln)
L. CO_2 emissions (kt) (ln)	0.280***		0.269***		0.286***	
L. CO_2 emissions (mt) per capita (ln)		0.241***		0.227***		0.247***
High-tech X	-0.023**	-0.030**				
High-tech X square	0.024***	0.028**				
Medium-tech X			-0.009*	-0.017**		
Medium-tech X square			0.016***	0.025***		
Low-tech X					0.030***	0.037***
Low-tech X square					0.031***	0.034***

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Conclusion

- Growing need to re-orient production processes and structures towards technology-based industries in DCs
- New evidence on the nexus between technology intensity, industrialisation and CO_2 emissions in developing countries
- Main finding suggests development stage and sub-sectoral content of manufacturing matters in mitigating CO_2 emissions
  - MHT manufacturing generally tends to be cleaner than low-tech manufacturing
  - M- and H-tech manufacturing (relative to low-tech manufacturing) are less polluting per unit of value added/exports

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Policy implications

- Shift to more tech-intensive industries to navigate the dual challenges of industrialisation and mitigating climate change
  - Key role of target sector-specific industrial strategies
  - Need to redirect policy towards more technology-intensive manufacturing for environmental sustainability
  - higher-tech industrialisation resolve the dual challenge and can provide a basis for high growth and catch-up.

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Policy implications cont.

- Under no illusion:
  - Industrialisation path could be environmentally destructive;
  - No ‘silver bullet’;
  - Effort and investment in human capital and in upgrading productive capabilities for MHT manufacturing needed
- Need for industrial and climate policy mix to achieve sustainable growth and development
- Further research

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Thank you!

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