RP2007

INTEGRATED CARBON METRICS - THE CARBON FOOTPRINT OF CITIES

Research Question (50 words)

How to calculate a city carbon footprint with complete scope 3 emissions? What are the carbon links between cities?

Methodology (75 words)

We introduce a new conceptual framework—based on environmental input-output analysis—that allows for a consistent and complete reconciliation of direct and indirect GHG emissions from a city. The "city carbon map" shows local, regional, national, and global origins and destinations of flows of embodied emissions (figure1).

Emissions are embodied in >	Melb-Prod	Mel-Prod	Mel-Prod	Mel-Prod	Mel-Prod	Mel-Prod	Mel-Prod	Mel-Prod	Mel-Prod	Mel-Prod	WoolM-Prod	WoolM-Prod	WoolM-Prod	WoolM-Prod	WoolM-Prod	WoolM-Prod	WoolM-Prod	WoolM-Prod	WoolM-Prod	WoolM-Prod
Origin of emissions v	GHG Emissions (kt CO_2eq)	Agric	Ind	Food	Goods	Elec	W/W	Transp	Constr	Govt	Biz	Agric	Ind	Food	Goods	Elec	W/W	Transp	Constr	Govt	Biz
Melb-Ind	Agric	217.9	0.2	279.0	29.8	0.5	0.9	6.2	82.8	38.1	121.6	0.11	0.05	0.07	0.04	0.01	0.02	0.003	0.08	0.22	0.003
Melb-Ind	Ind	2.1	674.6	87.0	532	84.2	21.3	43.1	477.5	147.8	542.6	1.34	1.08	0.33	4.47	0.37	0.32	0.11	1.05	2.31	0.06
Melb-Ind	Food	0.7	0.2	676.1	13.6	0.6	0.8	6.0	62.5	47.9	156.5	0.14	0.05	0.10	0.02	0.01	0.02	0.00	0.07	0.28	0.002
Melb-Ind	Goods	8.8	3.4	125.4	1,268	8.9	17.5	74.1	660.7	247.3	890.9	2.37	1.34	0.44	0.50	0.14	0.57	0.03	1.99	4.37	0.011
Melb-Ind	Elec	20.6	23.7	972	1,368	10,686	109.1	418.5	6,332	1,646	4,009	3.62	2.06	0.76	0.80	1.37	0.96	0.07	3.20	6.98	0.023
Melb-Ind	W/W	1.2	3.3	28.8	351.8	4.3	283.5	17.2	733.1	74.0	179.6	0.38	0.21	0.07	0.03	0.07	0.14	0.01	0.38	0.70	0.002
Melb-Ind	Transp	5.5	3.4	228.2	222.8	10.0	9.9	1,495	740.8	358.4	1,138	0.77	0.39	0.17	0.19	0.11	0.18	0.13	0.60	1.40	0.015
Melb-Ind	Constr	0.4	0.5	15.8	15.2	1.2	2.2	10.6	1,204	56.1	136.0	0.08	0.06	0.02	0.03	0.02	0.03	0.002	0.13	0.21	0.000
Melb-Ind	Govt	0.04	0.09	1.8	2.2	0.1	0.2	1.0	11.4	588.8	20.5	0.01	0.005	0.002	0.003	0.001	0.002	0.000	0.01	0.02	0.000
Melb-Ind	Biz	1.6	1.1	72.5	62.5	3.1	4.4	39.2	376.8	157.7	1,301	0.35	0.20	0.07	0.06	0.06	0.09	0.01	0.32	0.79	0.009
WoolM-Ind	Agric	85.2	2.8	3,044	411.5	10.1	13.3	78.3	778.0	513.7	1,492	4,677	28.9	776.7	487.0	8.6	14.8	22.2	64.9	174.9	26.5
WoolM-Ind	Ind	5.6	15.4	199.2	1,124	100.4	22.5	88.4	849	311.7	854	53.7	1,587	23.5	507.2	98.6	30.1	14.3	54.1	102.5	6.9
WoolM-Ind	Food	0.6	0.1	62.7	11.6	0.7	0.5	3.2	28.7	24.2	55.7	17.1	4.3	261.2	29.2	1.5	2.1	2.1	7.4	33.5	3.9
WoolM-Ind	Goods	15.9	8.3	392.4	781	28.6	37.2	183.2	1,584	760.9	1,444	220.3	124.5	128.1	5,410	35.8	60.8	109.6	182.8	391.8	49.4
WoolM-Ind	Elec	19.3	13.7	680.6	1,139	832.8	58.8	251.2	2,223	1,005	2,241	272.1	232.6	253.6	3,135	5,775	124.6	178.4	351.4	572.4	94.9
WoolM-Ind	W/W	0.9	0.4	23.3	26.4	2.1	2.8	6.3	77.3	25.8	58.6	20.3	12.9	7.3	67.0	6.3	188.6	3.6	36.0	37.5	1.9
WoolM-Ind	Transp	5.1	2.7	164.7	253.8	10.8	11.3	99.7	449.3	303.8	567.6	103.3	58.5	108.8	987	17.9	22.5	1,427	72.6	217.3	45.3
WoolM-Ind	Constr	0.2	0.1	7.0	9.5	0.8	0.4	1.8	20.7	8.0	17.4	6.3	7.1	3.3	24.5	1.9	3.5	3.3	86.5	23.1	2.3
WoolM-Ind	Govt	0.05	0.03	1.5	2.5	0.1	0.1	0.7	5.0	3.9	6.3	0.7	0.5	1.0	10.3	0.1	0.3	1.0	0.7	135.9	0.9
WoolM-Ind	Biz	1.3	0.6	41.1	47.3	3.1	2.0	10.7	94.2	47.7	109.9	38.5	23.5	23.7	178.4	7.3	11.2	16.4	41.9	103.3	49.5

Legend: Scope 1 (excl. exports); Scope 2; Scope 3; Scope 3 emissions of electricity use; Scope 3 emissions of electricity use already accounted for under Scope 1

Figure 1: an exemplary city carbon map for Greater Melbourne

Results (225 words)

Give a summary of your research results, in around 200 words.

In figure 2, Australian cities' CFs range from 11 t CO_2e/cap for Brisbane to 31 t CO_2 e/cap for Perth. The CFs of the four Chinese municipalities are 18, 17, 21 and 6.4 t CO_2e/cap for Shanghai, Beijing, Tianjin and Chongqing, respectively. The construction sector is the largest contributor in all cities. In Australia it represents 21–24% of the total CF, due to sustained growth in the population and the economy. In China, this share is even higher with 23–41%, which reflects a strong growth in the construction and real estate sectors following China's two-year 4 trillion Yuan (US$ 586bn) stimulus since 2008 to boost the economy mainly through infrastructure projects.

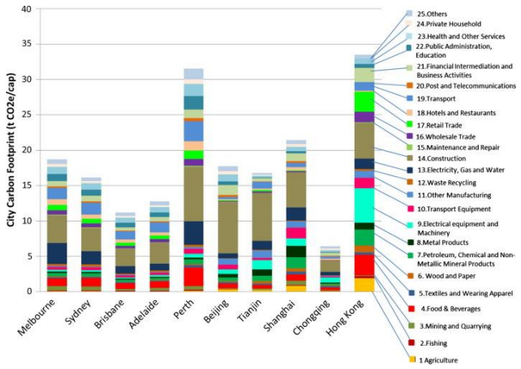

Figure 2: Total per-capita carbon footprints of Australian and Chinese main cities by sector (excluding direct emissions from households).

In figure 3, the carbon footprint networks are magnified for Melbourne with spatial and sectoral information to reveal 'hotpots' and possible priority intervention areas. From top to bottom, the emissions embodied in imports (EEI) from Rest of Australia, Rest of China and Rest of World make up the largest percentage of total EEI. The service sector from these regions contributes the largest amount, followed by manufacturing and construction. This reflects the large amount of imports of goods, materials and services by Melbourne residents. But in the manufacturing sector, Melbourne is exporting an even larger amount of embodied emissions than it imports, confirming Melbourne's position as a manufacturing hub.

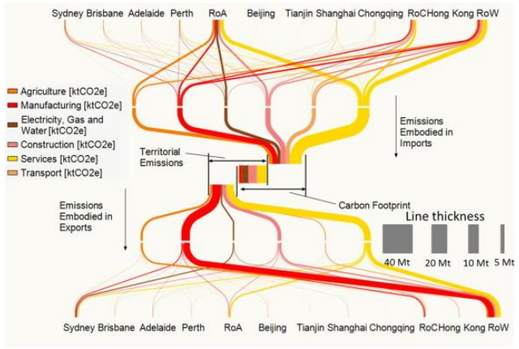

Figure 2: Flows of embodied GHG emissions related to Melbourne.

Conclusions (50 words)

This study conducts the first investigation into embodied carbon emissions of inter-city trade across countries. The results challenge the stereotypical view that developed countries generally shift the burden of GHG emissions to developing countries, which does not necessarily appear to be the case at the city level. Beijing and Hong Kong outsource more emissions than all the five large Australian cities combined (see figure 4).

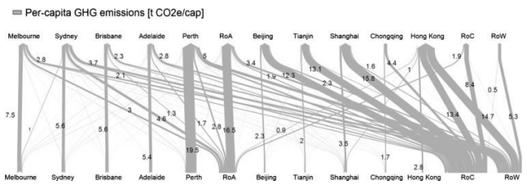

Figure 4: Inter-regional, per-capita flows of embodied carbon emissions instigated by city final demand, (the largest bilateral flows are labelled).

Anticipated impacts (50 words)

Our study also reveals new opportunities for joint responsibility and action, including direct investment in cities and regions which represent upstream GHG 'hotspots' related to city final demand. The method presented can assess the collective total impact of the commitments that cities made at the Paris Climate Conference.

Further information

Please read our recent publications

- Chen, G.; Wiedmann, T.; Wang, Y.; Hadjikakou, M. 2016.Transnational city carbon footprint networks–Exploring carbon links between Australian and Chinese cities. Applied Energy.
- Chen G, Wiedmann T, Hadjikakou M, Rowley H. 2016. City Carbon Footprint Networks. Energies. 2016;9:602.
- Chen, G., Hadjikakou, M., Wiedmann, T.O., 2016.Urban carbon transformations: unravelling spatial and inter-sectoral linkages for key city industries based on multi-region input-output analysis. Journal of Cleaner Production.
- Wiedmann, T. O., Chen, G. and Barrett, J. (2016) The Concept of City Carbon Maps: A Case Study of Melbourne, Australia. Journal of Industrial Ecology, 20(4), 676-691

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