The Impacts of Regional Production and Consumption Activity on Pollution Generation: Developing a User-Friendly Carbon Accounting Tool

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Accounting for pollution: Two Perspectives

- **Two perspectives for accounting for pollution generation/ resource use exist.**
- **The Production Accounting Principle (PAP)**
  - Pollution generated to meet domestic demand and foreign demand within a nation/regions own borders
  - Kyoto Protocol (1997)
  - Basis of EU and UK CO2 targets
  - Government or Local Authorities have control over production within their own borders
- **The Consumption Accounting Principle (CAP)**
  - Considers pollution generated to meet our consumption, business and Government decisions at home and in other countries.
  - Carbon Footprints- a 'full' measure of the pollution we generate to meet our demands (production and consumption
  - Government or Local Authorities do not have control over the production in other countries but can influence consumption/business demand within own borders?

How to Measure Pollution Generation

Input- Output Tables (IO) :

- Input-Output tables show the flows of all goods and services (in value terms) between local production and the final demand groups (consumption, government, investment and foreign)in an economy (national or regional), over the period of one year.
- Quantification of the links between the production and final demand in an economy.
- Calculation of 'output multipliers' – how 1 unit in final demand will impacts the local economy.

Input-Output tables (IO) to measure pollution generation:

- Accepted in the literature as a systematic way to account for pollution generation or resource use where physical pollution/resource data are available. (*Munksgaard and Pederson 2001*)
- At the EU level IO tables produced in the form of NAMEA
- UK Environmental Accounts
- Can attribute responsibility under both accounting perspectives.

Using IO as a 'Tool'

- Two hurdles with current IO methods:
  - Reliance of estimated data (black box)
  - Can be difficult to follow for policy makers and the wider community.

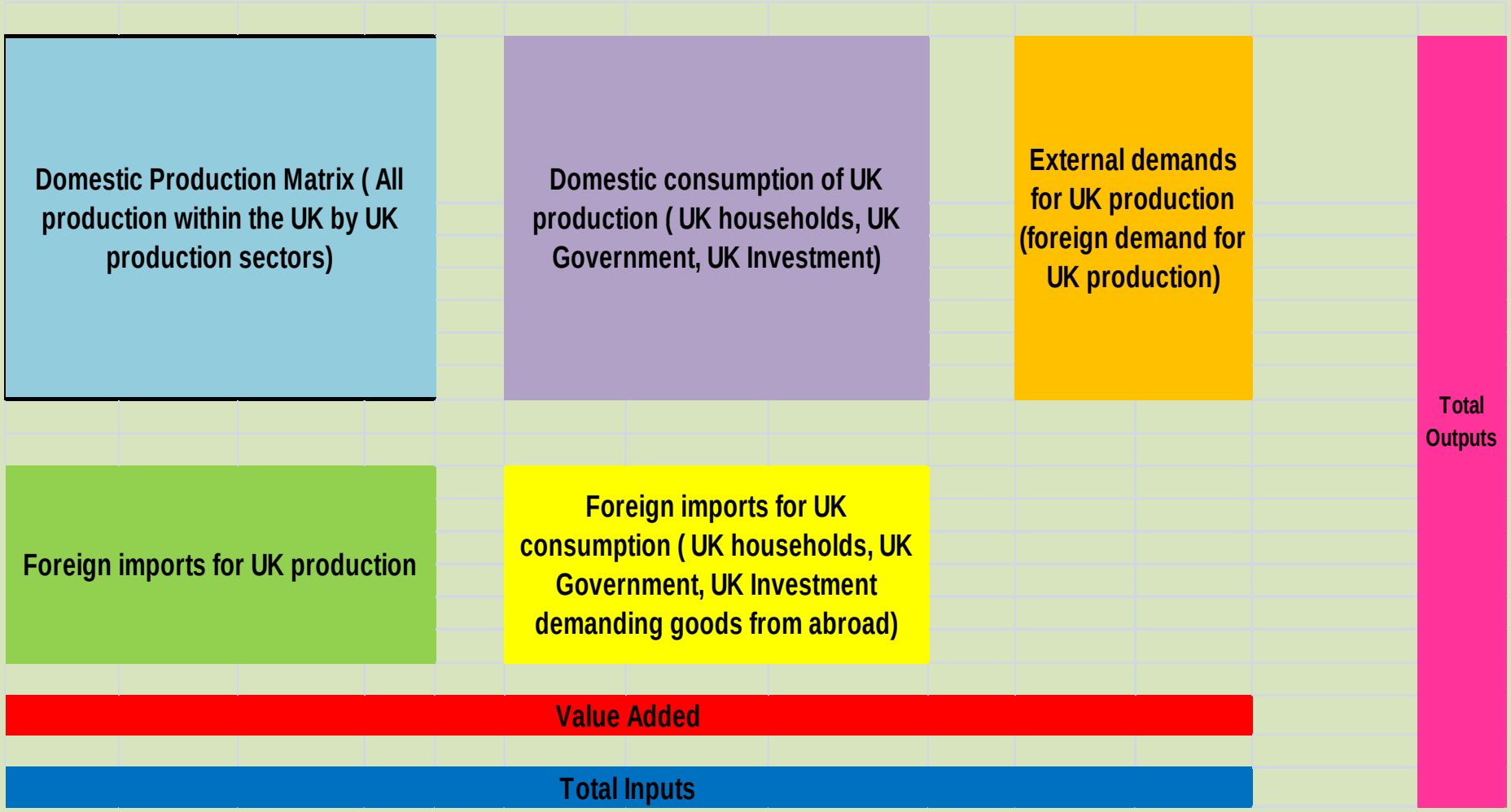
- Our Input Output framework : a simple 'tool'

  - Provides a transparent and systematic framework to consider pollution generation under either accounting/policy perspective.
  - Presents data in an easy to understand way which will allow deeper comprehension about sustainable issues and flows of pollution/resources.
  - Could be the start of a standardised measure across countries and allow for comparisons.
  - Provides a an economy-wide total for pollution generation but importantly can be used to understand what contributes to the total.

For National and Regional Policymakers

- Allow the evaluation of the success of policy goals through the creation of indicators of resource sustainability;
- Identify sectors or areas of the economy that could benefit from policy intervention;
- Provide a better understanding of supply chains and where major impacts occur within them, and
- Provide insight into the flows of such pollutants or resources embodied in products and services between the UK, the EU and the wider world.

Components of an Input Output (IO) Table- e.g. the UK



The IO Tool: Pollution to Meet Production

- Sum of all domestic pollution generated to meet domestic production, domestic demand and foreign demand.

- All data components for production accounting are from within the same country.

- To extend the production analysis:
  - Use the IO to trace back links in the economy that show which sectors /final demand groups are responsible for a larger share of pollution generation.
  - Understand how much pollution is attributable to foreign demand.
  - Generate multipliers to understand how one unit changes to final demand will impact the domestic pollution generation.
  - Multipliers also allow us to understand the direct and indirect impacts of changes to demand.

Production Accounting Principle (e.g. UK production for UK demand and foreign demand)
- Kyoto Protocol

Domestic Production Matrix (All production within the UK by UK production sectors)	Domestic consumption of UK production (UK households, UK Government, UK Investment)	External demands for UK production (foreign demand for UK production)
Foreign impo[illegible]K production	Foreig[illegible]imp[illegible] for UK consumption[illegible]useholds, UK Governm[illegible]vestment demanding goods from abroad)	

The IO Tool: Pollution to Meet Consumption

- Sum of all pollution generated to meet UK demand (at home and abroad).
- For a full footprint, all data components for consumption accounting are **not** from within the same country.
- We now require data on the production of the goods we import for production and consumption, and the associated pollution.
- The availability of data on the pollution content of imports presents a problem for consumption accounting, as does the lack of a comprehensive international database.
- Ideally require a world input output table
  - Many projects underway WIOD
  - Many analysts use GTAP data

Consumption accounting Principle (UK consumption of UK goods and foreign goods (imports))
- Carbon Footprint

Domestic Production Matrix (All production within the UK by UK production sectors)	Domestic consumption of UK production (UK households, UK Government, UK Investment)	External demand for UK production (Foreign demand for UK production)
Foreign imports for UK production	Foreign imports for UK consumption (UK households, UK Government, UK Investment demanding goods from abroad)	

One Way to Calculate a Consumption Measure Using the IO Tool (1)- The Economic Data

- Most countries/regions with an IO database will have fuller information in a combined use table- domestic goods and imports
  - Problem may be price base etc
- Use this to calculate multipliers
  - Losing the specific multiplier in the country importing from
- However , can think of a combined use multiplier as if only looking at part of the world that serves the consumption in the economy in question
- Benefit: Uses simple techniques that analysts in Government departments will understand
- Not an end point but a step towards the way in terms of:-
  - Clarifying and developing understanding of basic IO for pollution accounting
  - Helping to consider what questions need to be asked/should be asked/can be asked

One Way to Calculate a Consumption Measure Using the IO Tool (2)- Pollution Data

- Without country specific pollution/production data we can consider what would the UK emissions would be if other countries employed the *same* technology as the UK- Domestic Technology Assumption (DTA)
- Enables the calculation of a consumption measure.
- With the PAP and the CAP using DTA it is possible to observe an environmental trade balance between the home country and the rest of the world (importing sustainability?)
- Depending on data ,can disaggregate this further and observe trade balance between individual regions (e.g. the UK case).
  - Important for regional policy and devolution (measures set at the national and regional level)

If Country Specific Data on Imports are Available

- Relax the domestic technology assumption (DTA)
- With OECD data we have calculated a relaxed DTA consumption measure for the UK and Scotland-
  - Data from the OECD split out by sector and by country/region.
  - Attach actual pollution data from country by sector to imports
  - closer to a footprint measure.
- For an actual footprint measure a full set of sector/commodity pollution/resource use data would be required from every country that the UK or the regions imports from.
- This would require a full world input output table- already several projects underway
- Allows us to see the difference between the DTA and relaxed DTA
  - Questions over production technology and jurisdiction issues
  - Understand how close the DTA measure is to an actual measure

An example for the UK

- UK ONS – IO data in form of 123-sector (SIC) Supply and (combined) Use Tables, with physical data on emissions by each production sector and by households
- Environmental Accounts data for 93 sectors, maps to 68 sector aggregation of SUT
- SUT not appropriate format for multiplier analysis – wrong price base etc....inputs do not equal outputs for each sector (not symmetric)
- ONS not converted appropriate analytical format since tables for 1995
- Currently doing for 2005
- In meantime, with assistance from Scottish Government IO team and Stockholm Environment Institute, we have derived 2004 analytical IO, domestic use and imports – see Research pages at www.fraser.strath.ac.uk
- Relax DTA pollution assumption with data on (a) country/region source of imports; (b) associated direct CO2 intensities provided by OECD

Table 1. Input-Output Accounting of the UK CO2 Trade Balance (2004)

	Actual CO2 generation - PAP (Type 1)	Hypothetical generation - CAP (DTA)	Estimated CAP (relax DTA)
Total CO2 attributed (tonnes)	**643,806,114**	**712,677,329**	**813,536,304**
CO2 supported by UK household and government final consumption			
Domestic (UK) CO2 generation:			
Directly generated (households)	163,676,326	163,676,326	163,676,326
Indirect - generated in UK production sectors:			
Household	235,930,577	235,930,577	235,930,577
Government	50,032,572	50,032,572	50,032,572
Capital	41,479,167	41,479,167	41,479,167
	491,118,642	**491,118,642**	**491,118,642**
Indirect CO2 embodied in imports (hypothetical)			
Imports to households		149,133,532	232,247,838
Imports to Government		22,242,094	31,905,450
Imports to Capital		50,183,062	58,264,375
		221,558,688	**322,417,662**
CO2 supported by external demands for UK production	**152,687,472**		
Implied CO2 Trade Balance (Deficit):			
Actual CO2 generation minus DTA CO2 generation (CO2 embodied in exports minus CO2 embodied in imports)		**(68,871,216)**	**(169,730,190)**

UK Food and Drink 2004
-The additional value of the IO tool

- Using a sector example shows the added value of using the IO tool for measuring pollution generation.

- UK Food and Drink Sector from a **production** perspective
  - Transport costs will be reflected in the IO but distance not taken into account
  - Direct CO2 intensity of 151 tonnes of CO2 per £1 million output produced
  - 1.46% of direct CO2 emissions
  - Type I output multiplier 1.98 (0.98 multiplier effect)
  - Output pollution multiplier of 462 (462 tonnes per £1 million final demand for this sector)

  - Why then does it rise when we consider backwards linkages throughout the system?

UK Food and Drink 2004
-The additional value of the IO tool (2)

E.g. The UK Food and Drink sector purchases from the UK Agriculture sector which is a relatively CO2 intensive sector.

- 10% of total inputs to UK Food and Drink production come from the Agriculture sector
- Direct CO2 intensity of 285 tonnes per £1 million output IN Agriculture
- 31% of imports are Agriculture(not included under the PAP)

For every £1 million of final demand for the Food and Drink sector

- £0.12 million is required from the Agriculture sector
- This equates to 36 tonnes of CO2 produced in Agriculture
- Agriculture represents 8% of the total output-CO2 multiplier for the Food and Drink sector.

UK Food and Drink 2004
-The additional value of the IO tool (3)

- UK food and Drink Sector from a **consumption** perspective (a step towards a carbon footprint for the UK Food and Drink sector).

- Taking into consideration imports from abroad to UK Food and Drink
  - Still looking to the backward link with the Agriculture sector but now considering Agriculture imports from abroad to meet consumption demand for this sector.
  - Output multiplier rises from £0.12 to £0.21 million for every £1 million of final demand.
  - Now for every increase in demand (£1 million) additional imports are purchased
  - Output –CO2 multiplier rises from 35.5 tonnes to 60 tonnes per £1 million demand

- Using OECD data to relax the DTA assumption
  - Now 94 tonnes of CO2 per £1 million output
  - Other countries have dirtier Agriculture production compared to the UK so the pollution multiplier rises.

Sector/commodity	Share CO2 supported by external demand	Share of UK production (direct)	Share of UK final consumption (direct)	UK CO2 intensity (tonnes per £1m output)	UK CO2 Multiplier	Total consumption CO2 multiplier (DTA)	Global average CO2 intensity (tonnes per £1m output)	Total consumption CO2 multiplier (relax DTA)
UK aggregate	23.72%	100.00%	100.00%					
Food and Drink	15.80%	2.89%	3.48%	151	462	670	148	753
Agriculture	12.08%	0.98%	1.08%	285	553	736	450	954
Motor Vehicles	51.15%	1.99%	1.32%	50	394	840	31	826
Iron and Steel	72.55%	0.67%	0.02%	1,774	2,413	3,193	1,292	2,718
Air Transport	34.33%	0.68%	1.07%	2,668	2,958	3,245	4,763	5,618

Table 2. Input-Output accounting of Scottish CO2 generation

	2004 IO ACCOUNTING YEAR		
	PAP	CAP (DTA)	CAP (Relax DTA)
Total CO2 attributed (tonnes)	**66,711,016**	**69,021,834**	**77,759,681**
CO2 supported by Scottish final demands			
Domestic (Scottish) CO2 generation:			
Directly generated (households):	11,329,373	11,329,373	11,329,373
Indirect - generated in Scottish production sectors supported by:			
Households	15,288,628	15,288,628	15,288,628
Government	3,630,530	3,630,530	3,630,530
Capital	1,479,033	1,479,033	1,479,033
	31,727,564	**31,727,564**	**31,727,564**
Indirect CO2 embodied in imports (hypothetical)			
RUK			
Households		15,116,687	15,116,687
Government		1,912,391	1,912,391
Capital		2,753,704	2,753,704
		19,782,783	**19,782,783**
ROW			
Households		12,352,490	19,683,011
Government		2,078,502	2,840,354
Capital		3,080,495	3,725,969
		17,511,487	**26,249,334**
Total CO2 embodied in imports		**37,294,270**	**46,032,117**
CO2 supported by external demands for Scottish production			
Exports of goods and services RUK	27,584,391		
Exports of goods and services ROW	7,399,060		
Total CO2embodied in exports	**34,983,452**		
Implied CO2 Trade Balance (Deficit):			
Actual CO2 generation PAP minus estimated CAP			
(CO2 embodied in exports minus CO2 embodied in imports)			
RUK		7,801,608	7,801,608
ROW		(10,112,427)	(18,850,274)
Total		(2,310,819)	(11,048,665)

Table 1. Input-Output accounting of Welsh CO2 (as carbon) generation

		2003 IO ACCOUNTING YEAR	
		PAP	CAP (DTA)
Total CO2 (as carbon) attributed (tonnes)		**11,746,484**	**11,463,605**
CO2 (as carbon) supported by Welsh final demands			
Domestic (Welsh) CO2 (as carbon) generation:			
Directly generated (households):		2,130,600	2,130,600
Indirect - generated in Welsh production sectors supported by:			
	Households	1,397,716	1,397,716
	Government	551,445	551,445
		4,079,761	**4,079,761**
Indirect Carbon embodied in imports (hypothetical)			
	RUK		
	Households		2,433,967
	Government		568,028
			3,001,995
	ROW		
	Households		3,431,935
	Government		949,913
			4,381,848
Total carbon embodied in imports			**7,383,843**
CO2 (as carbon) supported by external demands for Welsh production			
	Exports of goods and services RUK	5,515,332	
	Exports of goods and services ROW	2,059,868	
	External tourists	91,523	
Total carbon embodied in exports		**7,666,723**	
Implied CO2 (as carbon) Trade Balance (Surplus):			
Actual CO2 (as carbon) generation minus DTA CO2 (as carbon) generation			
(CO2 (as carbon) embodied in exports minus CO2 (as carbon) embodied in imports)			
	RUK		2,513,337
	ROW		(2,321,980)
	Total (including external tourists)		282,879

Summary and Conclusions

- Building up in stages- ultimately want a full measure (e.g. when a world IO table is available)
- Developing understanding
    1. Fuller measure would give similar table of end results
    2. Flexible, transparent and systematic system

- Consider national GDP accounting
  - UN SNA require IO
  - Ability to consider direct and indirect effects
  - If everyone makes/ understands a simple framework first then collectively more areas of concern can be addressed
  - Like GDP accounting for pollution could be performed in the same way across countries- standard measure?